	Type	L #	Hits	Search Text	DBs	Time Stamp
1	BRS	L1	0	(automatic near enhancement) and (CAD and image)	USPAT; US-PGPUB; JPO	2003/10/15 10:11
2	BRS	L2	0	(automatic adj enhancement) and (CAD and image)	USPAT; US-PGPUB; JPO	2003/10/15 10:11
3	BRS	L3	21	(automatic adj enhancement) and image	USPAT; US-PGPUB; JPO	2003/10/15 10:15
4	BRS	L4	0	(automatic adj enhancement) and image and (CAD or CAM)	USPAT; US-PGPUB; JPO	2003/10/15 10:13
5	BRS	L5	0	(automatic adj enhancement) and (CAD or CAM)	USPAT; US-PGPUB; JPO	2003/10/15 10:13
6	BRS	L6	0	(automatic adj enhancement) and (redundant adj image)	USPAT; US-PGPUB; JPO	2003/10/15 10:15
7	BRS	L7	2	(redundant adj images) and optimize and 3D	USPAT; US-PGPUB; JPO	2003/10/15 10:23

	Comments	Error Definiti n	Err r s
1			0
2			0
3			0
4			0
5			0
6			0
7			0

US005806521A

United States Patent [19]

Morimoto et al.

[11] **Patent Number: 5,806,521**

[45] **Date of Patent: Sep. 15, 1998**

[54] **COMPOSITE ULTRASOUND IMAGING APPARATUS AND METHOD**

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[73] Assignee: **Sandia Corporation**, Albuquerque, N. Mex.

[21] Appl. No.: **622,129**

[22] Filed: **Mar. 26, 1996**

[51] **Int. Cl.**^{6} **A61B 8/00**

[52] **U.S. Cl.** **128/661.01**; 73/625

[58] **Field of Search** 128/660.07, 660.08, 128/660.09, 661.01, 916, 661.08, 661.09, 661.1, 660.04, 660.05; 73/625, 626

[56] **References Cited**

U.S. PATENT DOCUMENTS

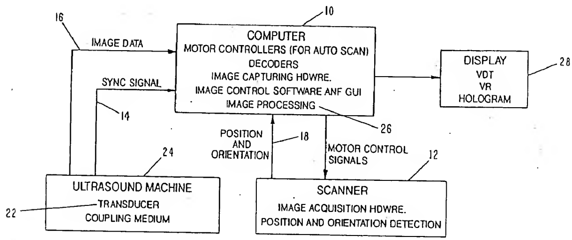
5,379,769	1/1995	Ito et al.	128/916
5,485,842	1/1996	Quistgaard	128/660.07
5,529,070	6/1996	Augustine et al.	128/660.07

Primary Examiner—George Manuel
Attorney, Agent, or Firm—Dennis Armijo; Gregory A. Cone

[57] **ABSTRACT**

An imaging apparatus and method for use in presenting composite two dimensional and three dimensional images from individual ultrasonic frames. A cross-sectional reconstruction is applied by using digital ultrasound frames, transducer orientation and a known center. Motion compensation, rank value filtering, noise suppression and tissue classification are utilized to optimize the composite image.

40 Claims, 37 Drawing Sheets



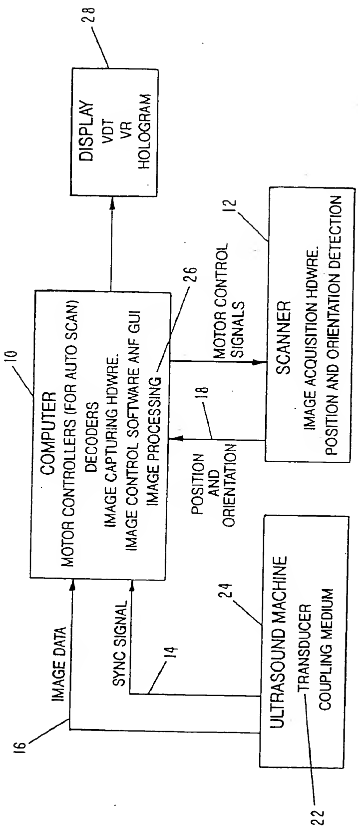

28
DISPLAY
VDT
VR
HOLOGRAM
10
COMPUTER
MOTOR CONTROLLERS (FOR AUTO SCAN)
DECODERS
IMAGE CAPTURING HDWRE.
IMAGE CONTROL SOFTWARE ANF GUI
IMAGE PROCESSING
26
MOTOR CONTROL
SIGNALS
12
SCANNER
IMAGE ACQUISITION HDWRE.
POSITION AND ORIENTATION DETECTION
18
POSITION
AND
ORIENTATION
24
ULTRASOUND MACHINE
TRANSDUCER
COUPLING MEDIUM
22
IMAGE DATA
SYNC SIGNAL
14
16

FIG — 1

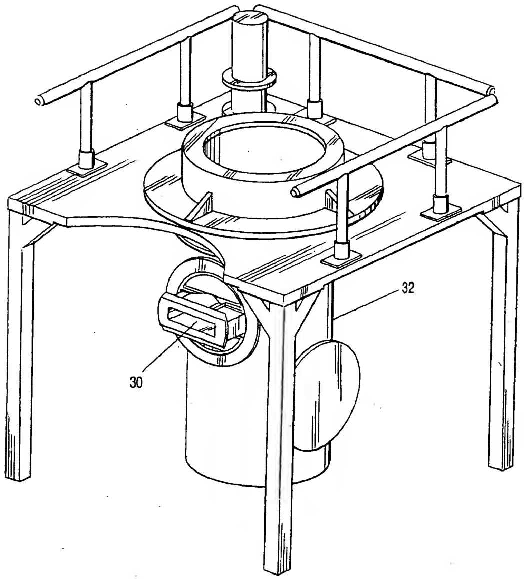


FIG-2

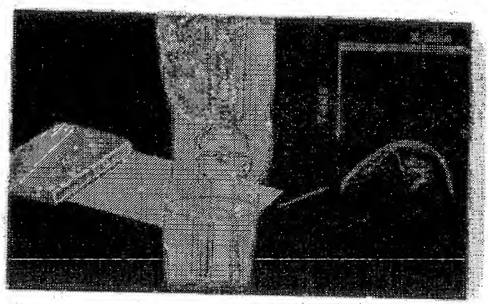


FIG. 3

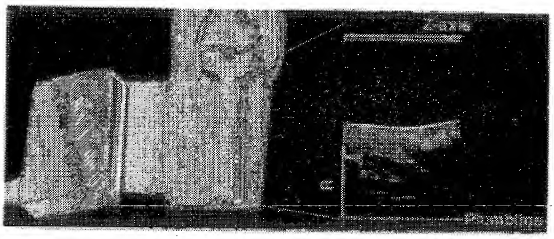


FIG-4

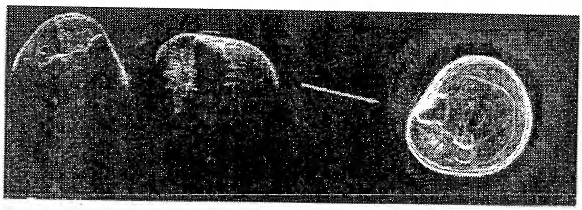


FIG-5

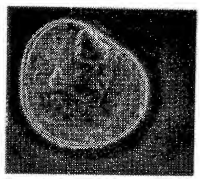


FIG-6

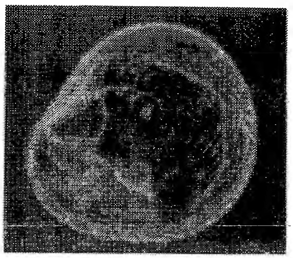


FIG-7

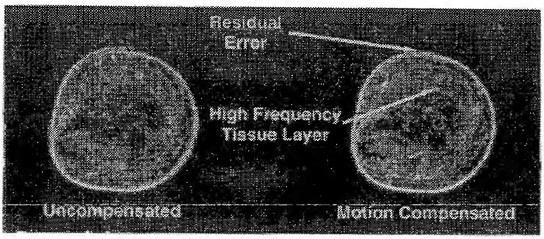
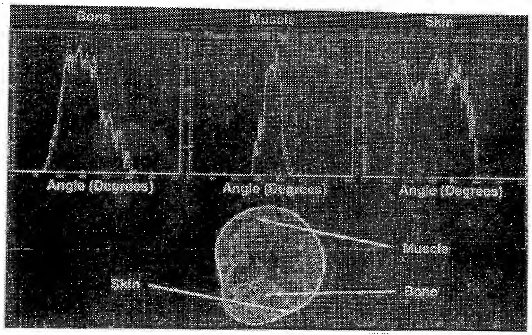

Residual
Error
High Frequency
Tissue Layer
Uncompensated
Motion Compensated

FIG-8



Bone
Muscle
Skin
Angle (Degrees)
Angle (Degrees)
Angle (Degrees)
Muscle
Skin
Bone

FIG-9

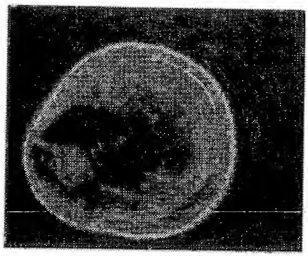


FIG-10

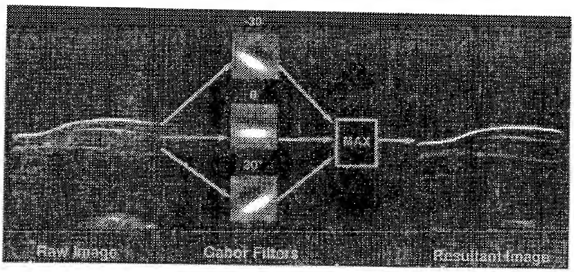


FIG-11

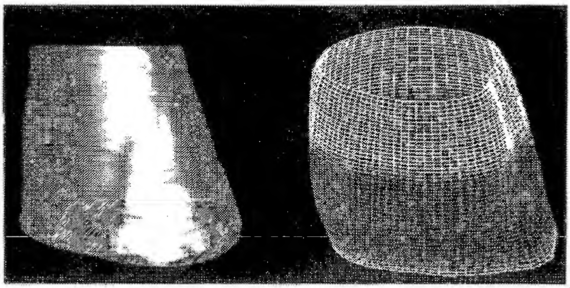


FIG-12

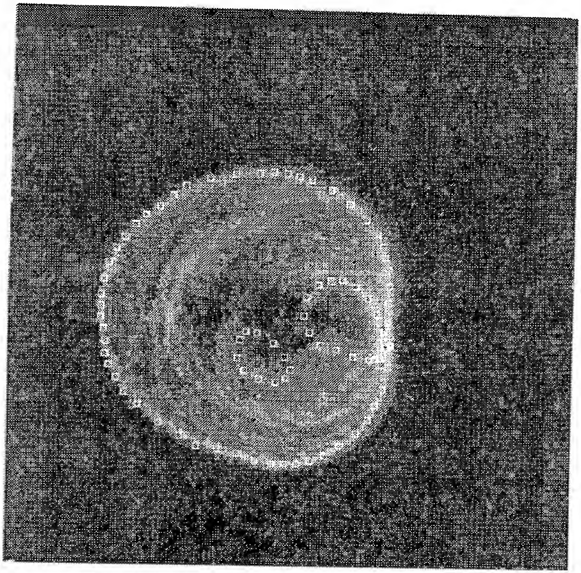


FIG-13

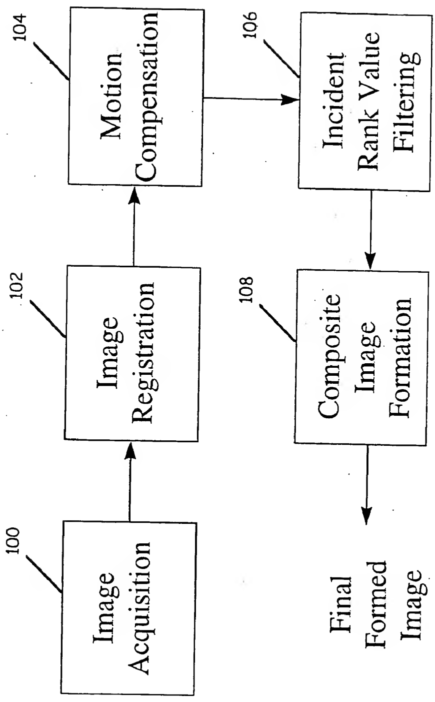

100
Image Acquisition
102
Image Registration
104
Motion Compensation
106
Incident Rank Value Filtering
108
Composite Image Formation
Final Formed Image

Fig. 14

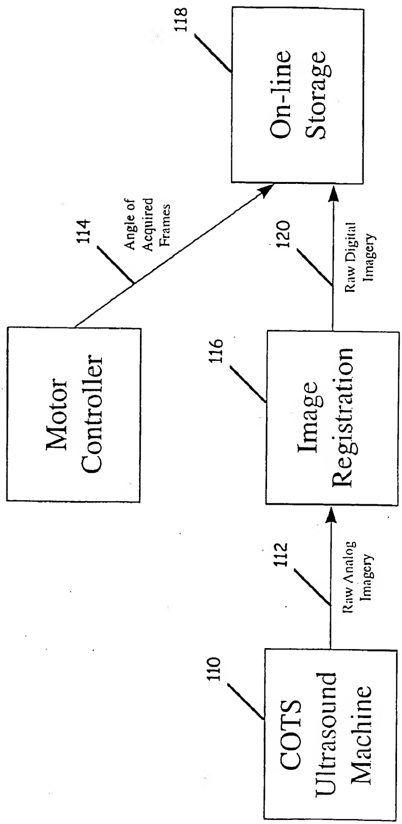

118
On-line Storage
114
Angle of Acquired Frames
120
Raw Digital Imagery
Motor Controller
116
Image Registration
112
Raw Analog Imagery
110
COTS Ultrasound Machine

Fig. 15

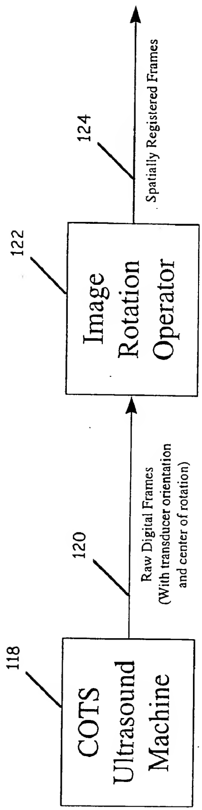

COTS Ultrasound Machine
118
120
Raw Digital Frames
(With transducer orientation and center of rotation)
Image Rotation Operator
122
124
Spatially Registered Frames

Fig. 16

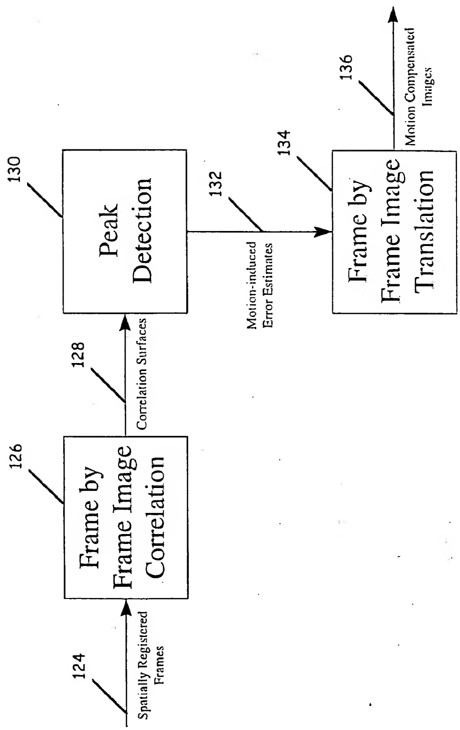

124
Spatially Registered Frames
126
Frame by Frame Image Correlation
128
Correlation Surfaces
130
Peak Detection
132
Motion-induced Error Estimates
134
Frame by Frame Image Translation
136
Motion Compensated Images

Fig. 17

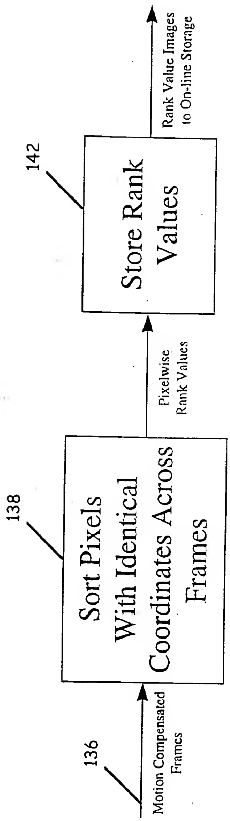

136
Motion Compensated Frames
138
Sort Pixels With Identical Coordinates Across Frames
Pixelwise Rank Values
142
Store Rank Values
Rank Value Images to On-line Storage

Fig. 18

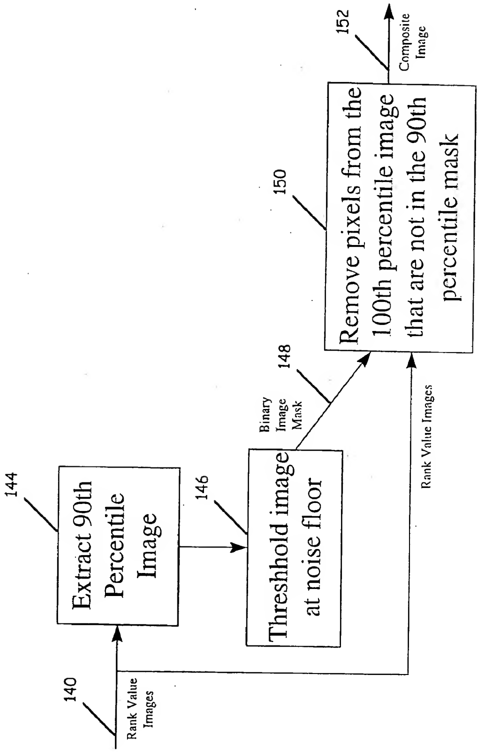

140
Rank Value Images
144
Extract 90th Percentile Image
146
Threshhold image at noise floor
Binary Image Mask
148
Rank Value Images
150
Remove pixels from the 100th percentile image that are not in the 90th percentile mask
152
Composite Image

Fig. 19

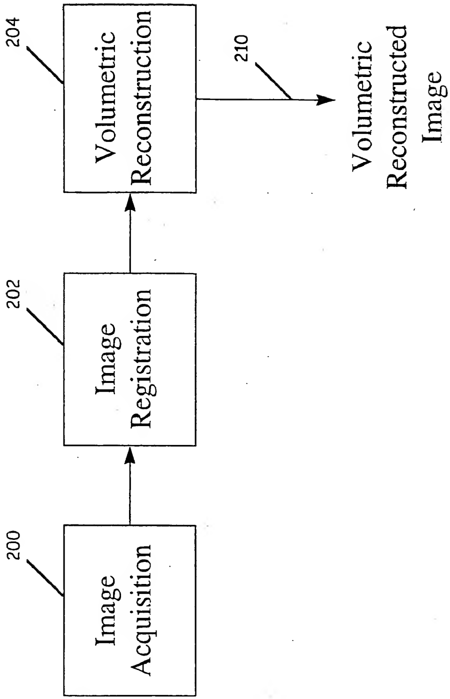

200
Image Acquisition
202
Image Registration
204
Volumetric Reconstruction
210
Volumetric Reconstructed Image

Fig. 20

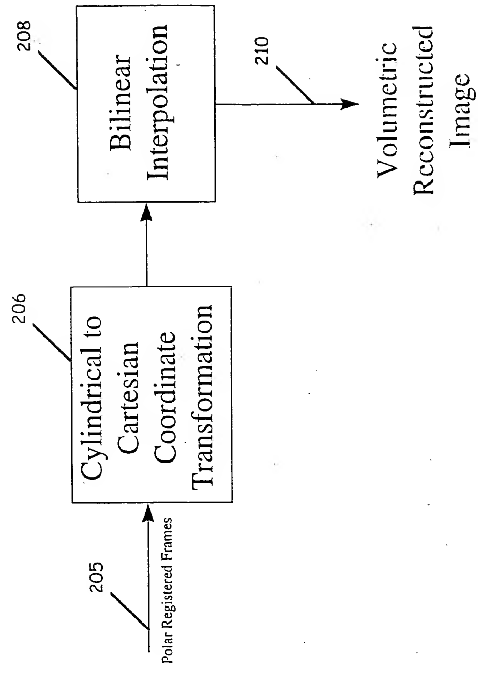

205
Polar Registered Frames
206
Cylindrical to Cartesian Coordinate Transformation
208
Bilinear Interpolation
210
Volumetric Reconstructed Image

Fig. 21

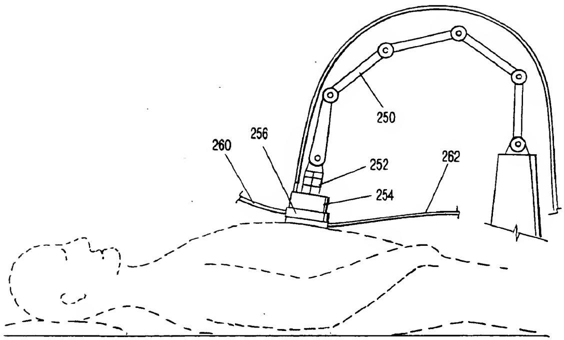


FIG-22

Fig. 23

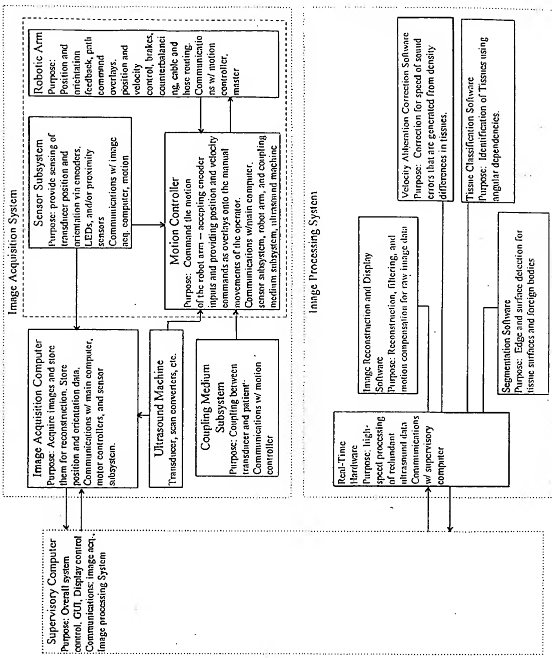


Image Acquisition System
Robotic Arm
Purpose: Position and orientation feedback, path command overlays, position and velocity control, brakes, counterbalancing, cable and hose routing. Communications w/ motion controller, master
Sensor Subsystem
Purpose: provide sensing of transducer position and orientation via encoders, LEDs, and/or proximity sensors
Communications w/ image acq. computer, motion
Motion Controller
Purpose: Command the motion of the robot arm -- accepting encoder inputs and providing position and velocity commands as overlays onto the manual movements of the operator.
Communications w/main computer, sensor subsystem, robot arm, and coupling medium subsystem, ultrasound machine
Image Acquisition Computer
Purpose: Acquire images and store them for reconstruction. Store position and orientation data.
Communications w/ main computer, motor controllers, and sensor subsystem.
Ultrasound Machine
Transducer, scan converters, etc.
Coupling Medium Subsystem
Purpose: Coupling between transducer and patient
Communications w/ motion controller
Image Processing System
Velocity Abberation Correction Software
Purpose: Correction for speed of sound errors that are generated from density differences in tissues.
Tissue Classification Software
Purpose: Identification of Tissues using angular dependencies.
Image Reconstruction and Display Software
Purpose: Reconstruction, filtering, and motion compensation for raw image data
Segmentation Software
Purpose: Edge and surface detection for tissue surfaces and foreign bodies
Real-Time Hardware
Purpose: high-speed processing of redundant ultrasound data
Communications w/ supervisory computer
Supervisory Computer
Purpose: Overall system control, GUI, Display control
Communications: image acq., Image processing System

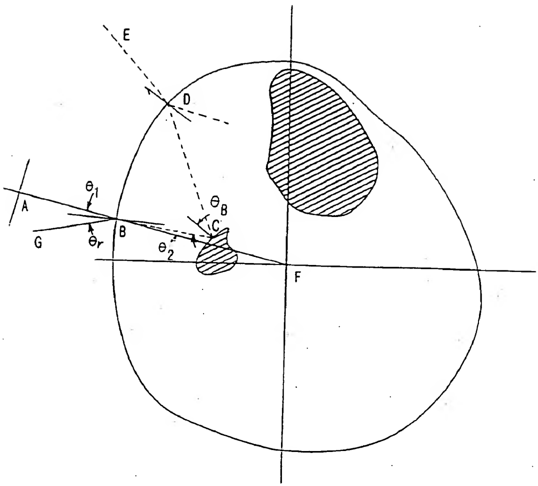


FIG-24

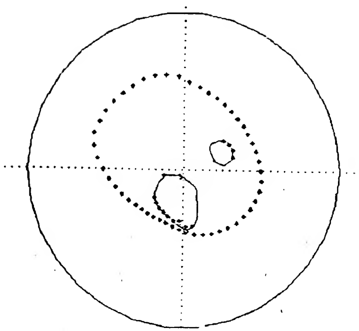


Fig. 25

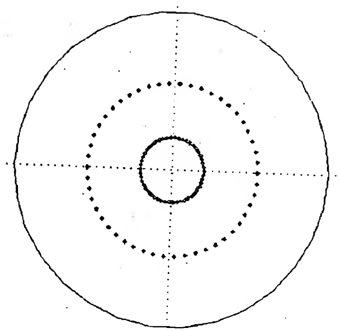


Fig. 26

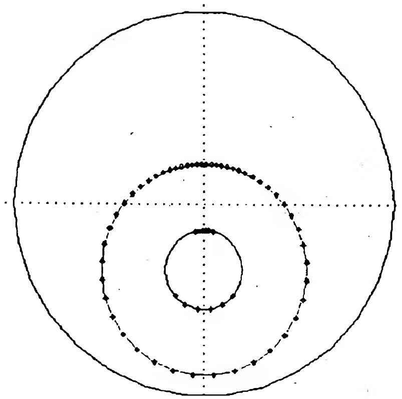


Fig. 27

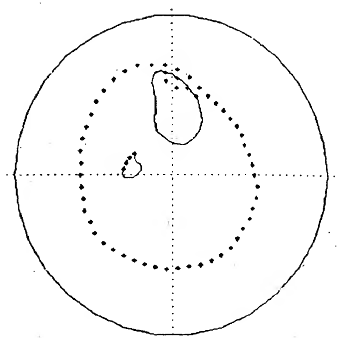


Fig. 28

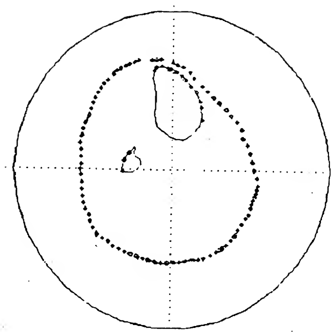


Fig. 29

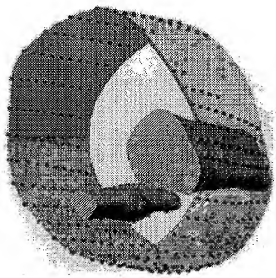


FIG-30

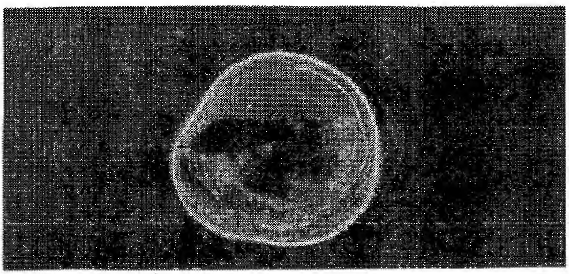


FIG-31

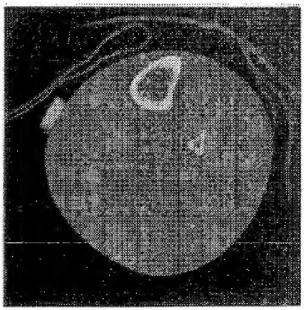


FIG-32

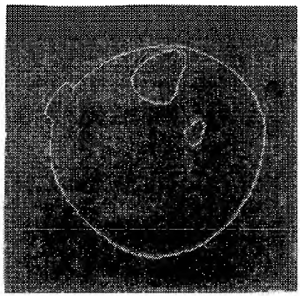


FIG-33

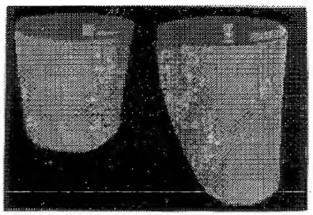


FIG-34

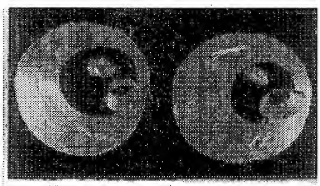


FIG-35

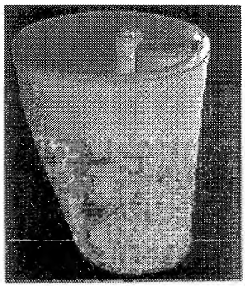


FIG-36

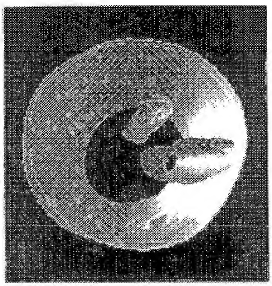


FIG-37

COMPOSITE ULTRASOUND IMAGING APPARATUS AND METHOD

This invention was made with Government support under Contract DE-AC04-94AL85000 awarded by the U.S. Department of Energy. The Government has certain rights in the invention.

BACKGROUND OF THE INVENTION

1. Field of the Invention (Technical Field)

The invention relates to imaging and more particularly to an apparatus and method of creating composite two dimensional (2D) or three dimensional (3D) video presentations utilizing ultrasound image data.

2. Background Art

Creating 2D or 3D images from different image sources is taught in several patents such as U.S. Pat. No. 5,099,846, to Hardy. However, the image data utilized in these devices is limited to expensive image sources such as computed tomography (CT), nuclear magnetic resonance (NMR), X-ray, and other known imaging modalities. These image sources contain sharp or clear image data, therefore filtering or image manipulation is relatively easy to do. The use of ultrasound images in these systems is absent due to the complexity of defining internal targets as opposed to mere surface location.

Complete images, including skin and bone have been obtained using either X-ray computer-assisted tomography (CT) or magnetic resonance imaging (MRI) but these methods have multiple disadvantages. Both of these procedures are costly and slow. Typical CT and MRI machines will cost several million dollars for initial purchase and can cost hundreds of thousands of dollars more for specialized facilities that provide shielding of patients and personnel. Furthermore, x-ray CT uses ionizing radiation that has been determined harmful to humans. Most computer workstations for this technology are based on proprietary technology and are limited to their ability to interface with other data processing systems. Because of these problems neither CT nor MRI systems are practical for regular use.

The present invention can be beneficial as a medical diagnostic tool, for example, for locating broken bones, certain targets or foreign objects in a body. Due to the small size and comparably inexpensive cost of an ultrasound system, the invention can be invaluable in the field or in a clinical setting where other more expensive imaging sources are not available.

Another example for the use of 3D ultrasound images is in the manufacture of prosthesis'. To accommodate individual differences current practice is to custom make each prosthesis. This process is time consuming, costly and requires a highly skilled prosthetist. Although prostheses have been improved in quality over the years based on improvements in the manual techniques and in the use of new materials, the basic techniques remain largely the same as in previous generations.

As patients walk and age, their residual limbs change shape due to atrophy of the soft tissue, as well as callousing, edema, scar tissue development, aging, and other complex processes. These changes alter the limb/socket interface and can result in pain or skin breakdown. The average amputee will need three to five new prostheses within the first five years after amputation because of changes in the residual limb that result in "socket failure". For each new prosthesis, the patient must undergo the entire measuring the fitting process and the prosthetist must begin anew the design and fabrication processes.

This situation is complicated by the fact that current design and fabrication procedures are more an artisan's craft than a science. Construction of the patellar-tendon-bearing (PTB) type device, which is best suited to ambulation of below-the-knee (BK) amputees, involves techniques that are labor intensive and result in inconsistent products. Acquiring data about the shape of the limb and identifying weight-bearing and potentially sensitive areas are critical early steps in ensuring an effective fit. It is important to note that the weight-bearing and sensitive areas are in close proximity to the underlying bone structure. It is necessary to modify the socket shape to provide pressure relief directly over bony prominences because pressure in these areas will cause immediate skin breakdown. Additionally, it is necessary to modify the socket shape to support the patient in areas that can bear weight. These weight bearing areas are identified by their proximity to the underlying bone structure. The prosthetist uses his/her experience and knowledge of anatomy to approximate locating the bone structure.

There are several disadvantages of this method. First, because the process is manual, the final fit depends entirely on the precision modeling of the leg. That leg model is generated in a step-by-step method that can create errors at each step. Second, the original model of the leg is not preserved during this process. Therefore, if at the end of fabrication, the prosthesis does not fit and cannot be adjusted, the entire process must be repeated. Finally, because the process is labor intensive and takes several days, the product is expensive.

As an alternative method to manual socket fabrication, computer-aided design and manufacturing techniques are now being applied to the problem of designing prosthetic sockets. The data required at the initial stage of socket design involves converting measures of residual limb shape into a computer-readable format. Several researchers have discussed methods of gathering shape data including the use of silhouettes, as shown in "Silhouette Shape Sensor", Smith, et al., *Bioengineering Centre Report*., pp. 41–42 (1986), digitizers, "Shoe Last Replication by Moire Contourography", Vickers, et al., *Proceedings of the 4th Rehabilitation Engineering Conference*, Washington D.C., August 1981, Shadow Moire Contourography, "Moire Contourography and Computer Aided Replication of Human Anatomy", Duncan, et al., *I Mech. Eng.* 9, 1980; "Shape Sensing for Computer-Aided Below-Knee Prosthetic Design", Fernie, et al., *Prosth. Orth. Int.*, 9:12–16, 1985, light streak shape sensing, *Proceedings of the '89 RESNA Annual Conference*, New Orleans, La. June 1989; "Computerized Tomography as an Aid to Prosthetic Socket Design", Faulkner, et al., *Rehab. R&D Prog. Rpt.*, 1:7–8, 1987, computer assisted tomography, "An Ultrasound Shape Sensing Mechanism", Faulkner, et al., *Presented at the 13th Annual Meeting of the American Academy* of Orthotics and Prosthetists, Tampa Fla. 1987, magnetic resonance imaging, "CAD/CAM System Applied to the Foot Shape for Prosthetic Device", Oshima, et al., *Proceedings of the RESNA 8th Annual Conference*, pp. 222–224, 1985, and linear potentiometers, "Socket Form Analysis of Computed Tomography Data", Faulkner, et al, *Journal of Prosthetics and Orthotics*, 1(3):154–164, 1989. Most of the work in this area has focused on utilizing surface shape data.

The most commonly used alternative system of acquiring shape data employs a mechanical digitizer that measures the inside of a plaster mold of the patient's residual limb. It provides relatively low resolution because of its indirect

nature and is not effective in digitizing the distal end of the residual limb. Non-contact laser imagers can also provide shape information. Scanning is completed in just a few seconds and relatively high resolution data can be acquired. Mechanical digitizers and laser imagers only generate surface topology data.

SUMMARY OF THE INVENTION (DISCLOSURE OF THE INVENTION)

In accordance with the present invention there is provided an apparatus and method for providing two dimensional or three dimensional images from an ultrasound transducer. The preferred apparatus of the invention is an apparatus generating a video presentation of ultrasound images comprising at least one ultrasound transducer, apparatus for acquiring a plurality of ultrasound images in scan increments of an object, an apparatus for converting the acquired images into a selected format, an apparatus for storing the converted images and apparatus for registering the converted images to generate a composite image of the object.

The preferred at least one ultrasound transducer comprises a two dimensional array of ultrasound transducers.

The preferred apparatus for acquiring a plurality of ultrasound images comprises a apparatus for acquiring data from known orientations and positions. The orientations comprise angles from a home orientation. The preferred apparatus for acquiring data from known orientations and positions comprises a feedback apparatus for optimizing a next scan. The preferred feedback apparatus comprises an apparatus for reorienting the at least one ultrasound transducer based on a previous scan's signal quality.

The preferred apparatus for acquiring data from known orientations and positions comprises a filter apparatus for acquired data reduction. The preferred filter apparatus comprises rank value filtering.

The preferred apparatus for acquiring data from known orientations and positions comprises overlapping converted images. The overlapping converted images comprise vertical overlapping images. The overlapping converted images also can comprise horizontal overlapping images. The overlapping converted images can also comprise overlapping images in any known angle between horizontal and vertical.

The preferred apparatus for acquiring data from known orientations and positions comprises a position transducer. The preferred position transducer comprises a member selected from the group of encoders, potentiometers, LVDT's, resolvers, magnetic encoders, and inductosync apparatuses. The apparatus for generating a video presentation with a position transducer further comprises a tachometer.

The preferred scan increments comprise surface normal optimization. The preferred scan increments comprise the composite image with an optimized intensity of predetermined anatomical features of the object. The preferred apparatus for registering comprises a transformation matrix apparatus for realignment of converted image data relative to home position orientation.

The apparatus for registering can further comprises an apparatus for object motion compensation. The preferred apparatus for object motion compensation comprises correlating overlapping converted image data. The preferred apparatus for acquiring data from known orientations and positions comprises apparatus for determining coordinates for selected targets within the object from the converted images.

A preferred method of generating a video presentation of ultrasound images comprises the steps of providing at least one ultrasound transducer, acquiring a plurality of ultrasound images in scan increments of an object, converting the acquired images into a selected format, storing the converted images and registering the converted images to generate a composite image of the object. The preferred step of providing at least one ultrasound transducer comprises providing a two dimensional array of ultrasound transducers. The preferred step of acquiring a plurality of ultrasound images comprises acquiring data from known orientations and positions.

The alternative step of acquiring data from known orientations comprises acquiring angle data from a home orientation. The alternative step of acquiring data from known orientations and positions comprises optimizing a next scan with feedback from a prior scan.

The preferred feedback comprises reorienting the at least one transducer based on a previous scan's signal quality. The preferred step of acquiring data from known orientations and positions comprises providing a filter for acquired data reduction. The preferred filter comprises rank value filtering.

The preferred step of acquiring data from known orientations and positions comprises overlapping converted images. The preferred step of overlapping converted images comprise vertically overlapping images. The alternative step of overlapping converted images comprise horizontally overlapping images. Another alternative step of overlapping converted images comprise overlapping images in any known angle between horizontal and vertical.

The preferred step of acquiring data from known orientations and positions comprises providing a position transducer. The preferred step of providing a position transducer comprises providing a member selected from the group of encoders, potentiometers, LVDT's, resolvers, magnetic encoders, and inductosync apparatuses. The preferred method further comprises the step of providing a tachometer.

The preferred step of acquiring a plurality of ultrasound images in scan increments comprise optimizing surface normal. The preferred step of acquiring a plurality of ultrasound images in scan increments comprises optimizing the intensity of predetermined anatomical features of the object from the composite image. The preferred step of registering comprises realigning the converted image data relative to home position orientation with a transformation matrix.

The preferred step of registering further comprises compensating for object motion. The preferred step of compensating for object motion comprises correlating overlapping converted image data. The preferred step of acquiring data from known orientations and positions comprises determining coordinates for selected targets within the object from the converted images.

A primary object of the present invention is to create two dimensional and three dimensional video presentations from a composite of ultrasound image data.

Another object of the present invention is to provide detailed information regarding an amputees bone and muscle structure for prosthesis fabrication.

Yet another object of the present invention is to provide a diagnostic tool for imaging internal organs and structures using ultrasound image data.

A primary advantage of the present invention is its low cost compared to other imaging modalities.

Another advantage of the present invention is that it uses non-ionizing radiation.

Yet another advantage of the invention is its portability.

Still another advantage of the present invention is the speed of creating the presentation compared to other imaging modalities.

Another advantage of the present invention is its ability to clarify the composite images by motion compensation and incident rank value filtering.

Other objects, advantages and novel features, and further scope of applicability of the present invention will be set forth in part in the detailed description to follow, taken in conjunction with the accompanying drawings, and in part will become apparent to those skilled in the art upon examination of the following, or may be learned by practice of the invention. The objects and advantages of the invention may be realized and attained by means of the instrumentalities and combinations particularly pointed out in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS.

The accompanying drawings, which are incorporated into and form a part of the specification, illustrate several embodiments of the present invention and, together with the description, serve to explain the principles of the invention. The drawings are only for the purpose of illustrating a preferred embodiment of the invention and are not to be construed as limiting the invention. In the drawings:

FIG. 1 is a block diagram of the preferred embodiment of the invention;

FIG. 2 illustrates the preferred hardware in accordance with the present invention;

FIG. 3 depicts a typical horizontal reconstruction;

FIG. 4 depicts a typical vertical scanning mode;

FIG. 5 depicts a typical rank filtering horizontal reconstruction based on maximum signal echo;

FIG. 6 depicts a typical horizontal rank value filtering construction;

FIG. 7 depicts a typical masked reconstruction;

FIG. 8 is a comparison of before and after motion compensated images;

FIG. 9 graphically show the angular dependency of skin, bone and muscle layers;

FIG. 10 shows one slice of a vertical reconstruction;

FIG. 11 illustrates the preferred skin recognition process;

FIG. 12 depicts a typical 3D CAD mesh and visual rendering of a composite image;

FIG. 13 is an example of segmented image with a user interface;

FIG. 14 is a block diagram of the preferred 2D horizontal scanning mode;

FIG. 15 is a block diagram of the preferred 2D horizontal image acquisition structure;

FIG. 16 is a block diagram of the preferred 2D horizontal image registration structure;

FIG. 17 is a block diagram of the preferred 2D horizontal image motion compensation structure;

FIG. 18 is a block diagram of the preferred 2D horizontal image incident rank filtering process;

FIG. 19 is a block diagram of the preferred 2D horizontal image composite image formation process;

FIG. 20 is a block diagram of the preferred 3D vertical mode functional overview;

FIG. 21 is a block diagram of the preferred 3D vertical mode vertical reconstruction process;

FIG. 22 depicts the preferred ultrasonic diagnostic system;

FIG. 23 is a flow chart showing the preferred ultrasonic diagnostic system;

FIG. 24 shows an ultrasonic sensor geometry modeled in computer software;

FIG. 25 is a simulated leg geometry with 50 sensors and 1 scan per sensor;

FIG. 26 is a simulated circle geometry with 50 sensors and 1 scan per sensor;

FIG. 27 is a simulated offset center circle geometry with 50 sensors and 1 scan per sensor;

FIG. 28 is an actual CT data scan;

FIG. 29 is demonstrates the use of multiple scans (5) at each of 30 sensors;

FIG. 30 is a three dimensional rendering of a leg;

FIG. 31 is an ultrasound cross-section;

FIG. 32 is a CT cross-section;

FIG. 33 is a resulting edge from a CT scan;

FIG. 34 is a side view of comparisons of three dimensional ultrasound and CT solid models;

FIG. 35 is a top view of the models of FIG. 34;

FIG. 36 is a side view of a registered ultrasound and CT volume; and

FIG. 37 is a top view of the volume of FIG. 36.

DESCRIPTION OF THE PREFERRED EMBODIMENTS (BEST MODES FOR CARRYING OUT THE INVENTION)

The ultrasound apparatus and method of the present invention comprises hardware components and associated software for providing two dimensional or three dimensional images of an object. Ultrasound can be argued to be the logical choice as an imaging modality because it provides surface and subsurface information about a body part or other object to be studied. In addition, ultrasound is a non-ionizing form of radiation and currently, there are no known harmful affects from FDA approved ultrasound machines designed for medical diagnostic imaging. Ultrasound machines are relatively low in cost (less than one hundred thousand dollars) as compared to CT or MRI. Most ultrasound machines provide resolution of images within a range that is acceptable for 3D imaging. For example, if the resolution in depth is 1.0 mm and the lateral resolution is 2.0 mm, relative accuracies of each modality are comparable at 1.0 mm. Image frame rates vary depending on the number of focal zones and the dept of penetration from 30 frames per second (fps) to 7 fps. The slower frame rates reduce the speed of image acquisition. Even at 7 fps, however, a complete image set, for example of a leg, of 400 images can be acquired within 72 seconds.

There are two preferred embodiments discussed, one for prosthesis fabrication, and the other for use as a diagnostic tool. Although these are the only applications disclosed, the present invention can be utilized in other applications that presently use known scanning and imaging modalities.

The preferred embodiment for prosthesis fabrication, of the invention is illustrated in FIG. 1. The 3D ultrasound imaging method and apparatus can be broken down into two separate sub-systems: image capturing and image processing. Image capturing comprises computer 10 that controls scanner 12 and inputs sync signal data 14, image data 16 and scanner position and orientation 18. The object to be scanned is placed in the scanning apparatus that can be

automatically or manually driven, such as the one shown in FIG. 2. Referring again to FIG. 1, in the automatic mode, scanner **12** is instructed via graphical user interface (GUI) **20** within the computer **10** to scan the object with a prescribed level of precision. In the manual mode scanner **12** is instructed to accept force commands from the operator by grasping and moving the end of scanner **12**. Thus scanner **12** positions and orients transducer **22** to maximize image data signal **16** to ultrasound machine **24**. Ultrasound machine **24** provides images that are captured by computer **10**. Both position and orientation data **18** and images are stored simultaneously in computer **10** for reconstruction purposes. GUI **20** controls the position, orientation, and resolution of each scan and can also request historical data such as patient name, date and time of scan.

The image processing subsystem takes the raw data acquired in the image capturing subsystem and forms a composite image of the anatomy that is scanned. Composite image is then processed using special image processing software **26** to enhance image quality. Motion compensation and filtering are performed prior to extraction of the skin and bone surface geometry. Image processing **26**, motion compensation filtering are described herein. Data from skin and bone surface geometry can be used to fabricate custom worn devices such as prostheses.

A visual presentation of the composite images is provided via display **28**.

FIG. **2** shows the preferred mechanical scanning system for prosthesis fabrication consisting of transducer holder **30**, scanning tank **32**, servo motor, and motor controller (not shown). Transducer holder **30** is a bracket that holds the transducer in a rigid fashion and maintains the position and orientation of the transducer in the scanning tank window. The scanning tank window is a flexible membrane that keeps water in tank **32** and allows ultrasound to penetrate without attenuation. Scanning tank **32** is filled with water for transmission of ultrasound for non-contact scanning of variable size legs. Non-contact scanning is essential for definition of "unloaded" soft tissue surfaces.

The tank diameter (preferably 11.5 inches) can be used to accommodate the largest amputee leg size while optimizing the ultrasound, penetration range. Other sized tanks can be used for different body parts or targets for scanning. For the frequency of ultrasound, preferably 3.5 MHZ, the depth of penetration is limited to 22 centimeters or 8.7 inches. At this frequency, data can be scanned beyond the center of the tank. This frequency must be altered to accommodate larger diameter tanks. Thus, any object within the tank can be imaged without strict restrictions on its location. Servo motor (not shown) is controlled by position and velocity so that the proper number of frames can be captured around the leg. With position and velocity control, the servo-controlled scanner can be varied during image capturing. Thus, leg regions that are of more interest can be scanned with finer resolution of spacing then other regions. The position of the frame capture is recorded along with the image. This information allows the image processing package to reconstruct the images based on the raw data.

The configuration of the three dimensional ultrasound scanning system allows for variations in the orientation of the ultrasound transducer. The two orientations are vertical (linear array oriented parallel to the long axis of the leg) and horizontal (linear array oriented transverse to the long axis of the leg).

With the vertical orientation, scanning of the transducer circularly around the leg generates a volumetric data set. The

resolution of image spacing is measured in degrees. With variable scan rates, the bony regions of the leg are scanned with finer resolution that the soft tissue regions. Regardless of the resolution of image capture, there remains a space between captured data sets that is unaccounted for. In order to provide smooth transitioning between images, interpolation is used.

With the transducer oriented horizontally, circular scanning of the transducer generates a planar image of the transverse cross-section. The data set is redundant with each point in the leg imaged multiple times at the different angles. The advantages provided by this method of scanning are many. Since each anatomical location within the leg is imaged multiple times, image processing algorithms can be used to optimize the image based on the data. Consequently, the image with the most detail can be generated where each pixel within that image has been optimized for brightness and clarity. The resulting images from this technique can be used for diagnostic imaging that is comparable to the resolution of x-ray computed tomography. In fact, because ultrasound is better suited for soft tissue definition than is x-ray, ultrasound images demonstrate clearer tissue interfaces. Volumetric image sets can be generated from horizontal scans by swiping the transducer vertically.

The preferred ultrasound image acquisition system consists of Motorola 68030 based CPU, or the like, video frame grabber, motor controller, and an additional memory board, all housed in a VME bus based enclosure. A Sun-based graphical user interface (GUI), or the like, is used for command and control of the entire system.

Utilizing the GUI, the operator can select the number of images to acquire from the ultrasound machine, choose the start and stop position of the scanner, as well as several other variables for correct operation of the system. Images can also be selected at constant or variable spaced intervals about the subject's leg.

The VME CPU performs the following functions:

a) Reads the command from the operator and calculates the correct rotation rate for the scanner;
b) Commands the scanner to start rotating;
c) Continuously monitors the position of the scanner to decide when to grab the next ultrasound image;
d) Grabs an image and stores it in memory; and
e) On command from operator all images are transferred via Ethernet to host computer when operation is complete for post processing and image reconstruction.

At the present time the output image data from most ultrasound machines is in analog format, and therefore must be digitized. It would be advantageous to obtain the data at the digital level, prior to image processing and output the video image.

Image capturing and scan speed preferably are synchronized to a seven (7) Hertz image frame rate. This signal can be incorporated into the system.

Ultrasound is most accurate when the beam is incident normal to the surface of the subject. As the angle between the transducer and the surface normal increases, image quality rapidly drops off due to reduced pixel intensity and inaccurate distance representation.

The image quality of a leg is best when the incident angle is between +/- ten (10) degrees as the intensity values in the bone and skin images drop noticeably at larger angles. Image quality is best when ultrasound incident angles are between +/- ten (10), and inaccuracies in distance representations in the images occur with incident angles greater than +/- twenty (20).

The preferred prosthesis limb scanning apparatuses and methods acquire ultrasonic images in two modes: horizontal and vertical. In the horizontal scanning mode, individual frames are acquired at a predetermined angular increment about the limb, as depicted in FIG. 3. A cross-sectional reconstruction process is then applied which involves angular rotations, motion compensation, and rank filtering, resulting in a highly defined planar cross section of the limb.

In the vertical scanning mode, the transducer is oriented parallel to the vertical axis of the tank. Individual frames are acquired at a predetermined angular increment about the limb, as is seen in FIG. 4. A reconstruction process is then applied which involves angular rotations and polar interpolation, resulting in a volumetric reconstruction. The image and signal processing software developed for processing ultrasonic images can been integrated into the Khoros system, which is an algorithmic development and visualization environment.

In the horizontal scanning mode, the linear transducer is oriented parallel to the bottom of the tank. In this mode, the x axis corresponds to the coordinate axis along the face of the transducer (or cross range), the y axis corresponds to the depth of penetration, or the direction along which sound travels into the tank (or range), and e corresponds to the clockwise angle of the acquired frame with respect to the top, or front, of the limb. See FIG. 3.

In this mode, a mechanical scanning system rotates the ultrasonic transducer about the limb. During the scanning process, individual ultrasonic frames are digitized along with the angle (Θ) of the acquired frame. The reconstruction process involves rotating the individual frames about the center of the trunk. In this reconstruction process individually captured images are rotated with respect to the initial coordinate frame, and all frames are co-registered and combined to generate a composite image. It can be seen from the scanning geometry (FIG. 3) that an individual point within the limb will be visible to the transducer as the transducer sweeps through an angular spread.

For prosthesis fitting, the points of interest are the surfaces of the tibia, fibula, and skin. Both bone and skin in ultrasound data show up as relatively strong signal echoes. Exploiting the redundancy in the data, the maximum signal echo can be chosen from all those signal echoes corresponding to any given point within the limb. The resultant cross section reconstruction seen in FIG. 5 emphasizes the strong signal echoes of the skin and bone, but at the cost of also emphasizing any noise in the system, such as the tank noise around the limb.

The noise signal echoes (tank reflections, bubbles etc.) are not coherent additions to the signal. Instead, the ultrasonic limb signal echoes replace noise signal echoes when present. The preferred technique under these circumstances is to use a rank value filter that employs a percentage ranking of the frames (instead of the average value over N frames) which preserves the desirable signal echoes (of the limb) while it eliminates the undesirable signal echoes (from the tank noise). Using the technique, FIG. 5 (the maximum signal echo) represents the 100% ranking. In using this technique applied to the data set corresponding to that in FIG. 5 and choosing the 90% ranking, it produces the reconstruction shown in FIG. 6.

Further, using the non-zero values of the reconstruction in FIG. 6 as a mask to the reconstruction shown in FIG. 5 produces the masked reconstruction shown in FIG. 7. This combination simplifies the task of recognizing the skin and bone signal echoes from within the reconstructed images because it maximizes the signal strength of the skin and bone surfaces while reducing noise.

A horizontal scan that is generated between forty (40) and one hundred eighty (180) frames will typically require 10–30 seconds to complete. Even during this short period of time patient motion can cause discontinuities in the reconstructed image. Any mechanical method to constrain the motion of the limb will distort the unloaded skin surface. Consequently, a small amount of motion during the scan should be expected. Any motion during the scan will manifest itself as a blur in the reconstructed image, thus adversely affecting the overall image. Depending on the angular increment of successive frames of the acquisition (typically four (4) degrees), the majority of the information results from the same geometry within the limb. Because of this redundant information from frame to frame the data are highly correlated. Any motion of the limb between the acquisition of two frames will result in a shift of the correlation peak of the two frames with respect to each other corresponding to the amount of relative motion. The compensation for such motion is shown in FIG. 8.

In the motion-compensated reconstruction image (FIG. 9), the error has been reduced but not eliminated. This is a result of the integrated residual error over the entire scan. In the motion-compensated reconstruction, the more high spatial frequency information of the structure of the internals of the limb is present.

At first order, the ultrasonic signal echoes of a limb typically exhibit either reflective (specular) or volumetric scattering characteristics. Any given tissue type (bone, skin, muscle layers, etc.) is usually dominated by one of the characteristic types. Specular signal echoes usually fall off quickly with changes in angles of incidence as compared to scattering signal echoes. During an acquisition scan, a two dimensional angle of incidence (versus signal echo value) can be generated for each point within the reconstructed image. Then, the angular dependency of a given point within the limb can be determined. Then, a classifier can be designed to recognize the differences in tissue type based on their angular dependency.

From within the reconstructed image in FIG. 9, three points can be selected which correspond to a skin signal echo, bone signal echo, and a muscle layer signal echo. The plots exhibit the angular dependencies of these three tissue types. Notice the specular nature of both the muscle and bone, while the skin is much more scattering in nature.

In the vertical scanning mode, the transducer is oriented parallel to the vertical axis of the tank. In this mode, the z axis corresponds to the individual ultrasonic transducer number (or height, increasing going up the limb), the r axis corresponds to the radius from the center (plumb line) of the tank, and Θ corresponds to the clockwise angle of the acquired frame with respect to the top or front of the limb. See FIG. 4.

A mechanical scanning system rotates the ultrasonic transducer about the limb. During this process, individual ultrasonic frames are digitized along with the angle Θ of the acquired frame. The reconstruction process involves rotating the individual frames about the center of the tank. This process produces a series of frames which represent the ultrasonic signal echoes of the limb as the transducer is rotated about the limb. By contrast to the horizontally oriented transducer, where redundant information exists from frame to frame, individual points within the limb are observed only once during the scan, and some parts will not ever be visible to the transducer. See FIG. 4.

A bilinear interpolation scheme is employed to produce a volumetric reconstruction of the limb. The bilinear interpolation is carried out for a given z (height) value, which

corresponds to a cross sectional plane of the reconstructed limb. The acquired data are presented in polar coordinates, but it is desirable to perform the reconstruction in Cartesian coordinates. Consequently, a polar to Cartesian transformation is performed on the acquired data. For each point in the reconstructed plane, the four "surrounding" points from the acquired data are determined. A bilinear interpolation is performed to determine the value of the reconstructed point. The result is a "stack" of reconstructed cross sections of the limb, one corresponding to each z (height) value. See FIG. **10**.

An individual frame from a vertical acquisition is shown in FIG. **10**. This image corresponds to a vertical slice through the limb. The skin is recognized by correlating set of gabor filters, oriented at −30, 0 and +30 degrees, with the individual frame and determining the maximum response to the set of filters. See FIG. **10**. The size of the gabor kernels is determined by heuristic examination of ultrasonic skin signal echoes. The leading edge of the skin response can then determined from heuristic examination of responses to the gabor filters. See FIG. **11**.

The skin locations are recorded in the form r, z, Θ. These sets of points give rise to an overall three dimensional (3D) description of the skin surface of the limb. This 3D description can be entered into a CAD package for potential fabrication of a prosthesis, or any 3D rendering package. See FIG. **12**.

Image processing operations can be performed within Khoros, which provides an environment for image processing algorithm exploration with industry standard routines for basic image conversion, processing, and display. Application-specific routines can be integrated into the Khoros system. They may contain calls to standard Khoros library functions or user written library functions that add new functionality to the system.

A Visual Programming Environment (VPE) is also provided that allows Khoros users to direct inputs through a series of these library functions and display the results. With Khoros, a new algorithm can be rapidly prototyped and handed off to image analysts for review. The VPE can also be used by the image analyst for production work. Nine ultrasound specific application routines can be utilized and integrated into the Khoros system. These routines include:

gabor—a routine used to generate a kernel containing a gabor function. The kernel can have arbitrary orientation and size. The Gabor program can generate both even and odd gabor functions.

ncorr—will calculate the normalized correlation of a kernel with an input image. The resulting image will be the extent of the input image. Normalized correlation is only calculated for those positions in which the kernel fits entirely within the input image. Edge effects are not handled.

us2viff—"Ultrasound to Visualization Image File Format (VIFF)" conversion—us2viff takes the raw individual ultrasound frames in conjunction with the acquisition header information (sensor orientation, acquisition angle, date, time, subject, machine characteristics) and produces a multiband VIFF image file. The individual frames are stored as bands in the multiband image.

ush2dxs—"Ultrasound horizontal two dimensional cross section generation" —ush2dxs rotates the individual frames about the plumb line to the angle which corresponds to the actual acquisition; compensates motion between the individual frames; and determines the maximum response throughout the frames on a pixel by pixel basis to produce a composite cross sectional ultrasonic image.

ushmocomp—is used to compensate the individual ultrasound frames for motion of the limbs between successive frames. It exploits the highly correlated nature of successive frames and determines the amount of motion by the shift in the correlation peak.

ushplumb—is a calibration verification tool which will recognize the signal echo of a plumbob within the ultrasound imagery to verify the proper orientation of the sensor with respect to the center of the tank. Statistics are generated for both leading edge and maximum point signal echoes of the plumbob.

ushrank—"Ultrasound horizontal rank value cross sections generation"—rotates the individual frames about the plumb line to the angle which corresponds to the actual acquisition; motion compensates motion; and ranks, across all frames, the individual pixel values to produce a set of ranked cross sections. These cross sections can be chosen to filter out incoherent noise, or other undesirable signal echoes.

usv3dxs—"Ultrasound vertical three dimensional volumetric reconstruction"—rotates (about the plumb line) the individual frames to the angle which corresponds to the actual acquisition; performs polar to Cartesian coordinate system transformation, and then executes a bilinear interpolation scheme to produce a series of two dimensional cross sections. The resulting "stack" of two dimensional cross sections is then assembled to produce an overall volumetric reconstruction of the limb.

usvskin—uses the individual vertically scanned frames to create a 3D description of the skin surface. The skin is recognized by applying a set of gabor filters to the individual frames and determining the maximum response to the set of filters. The skin location or leading edge of the skin response is saved in the form r, z, Θ). These sets of points give rise to an overall 3D description of the skin surface of the limb.

Skin and bone surface segmentation can be performed from vertical scans with a flexible, interactive program that displays horizontal cut images made from the vertical scans. The program works on one cut at a time. The user begins the segmentation by providing an initial approximation on one cut. An automated segmentation program then takes over to refine the initial approximation. The final result is a file of three dimensional points made up of all the cuts. An example of a segmented image with the user interface is shown in FIG. 13.

The user provides initial approximations of discrete contour points that give a rough outline of the skin and two bones. The graphical user interface displays the image data and gives mouse-driven, or the like, controls for making these approximations. To approximate the outline of the skin, the user sets a gray-level threshold that separates the darker image background from the brighter pixels on the skin. A radial line is traced from the outer edge of the image toward the center. The first skin point is taken at the place where this line first crosses the threshold. Starting from this point, the program traces the remainder of the skin by looking for nearby above-threshold values. The two bone contours come from pre-stored, approximate outlines of typical bones consisting of about 20 points each. The user drags these contours to the approximately correct location on the image. The program allows the user to rotate and scale all the contours and to move individual points of the contours.

These initial approximations serve as the starting point for the automatic segmentation program. This program refines

the discrete contour points to make them fall precisely on the bright ridges in the image. The automatic segmentation program uses active contours called "snakes". Snakes work by solving an energy minimization problem for each contour. The "energy" is a sum of the (negative) pixel brightness along the contour and the bending energy of the contour. The bending energy is proportional to a weighted sum of the first and second derivatives along the contour. The positions of the contour points are iteratively moved to minimize the total energy. The brightness term tends to move the points toward image maxima, while the bending terms tend to keep the contour smooth. Together, these terms make the contour track bright ridges in the image while remaining smooth through gaps and noise.

Image processing in the horizontal scanning mode is depicted in FIG. **14**. Individual ultrasonic frames are acquired at a predetermined angular increment about the scanned object (in this case a lower human limb). A cross-sectional reconstruction process is then applied which involves image acquisition **100**, image registration **102**, motion compensation **104**, incident rank value filtering **106** and composite image formation **108**.

The image acquisition process and structure as shown in FIG. **15**, comprise a commercial off-the-shelf (COTS) ultrasound machine **110**. A linear ultrasonic transducer is oriented parallel to the bottom of the tank and transverse to the scanned object. In this mode, the x axis corresponds to the coordinate axis along the face of the transducer (or cross range), the y axis corresponds to the depth of penetration, or the direction along which sound travels into the tank (or range), and theta corresponds to the clockwise angle of the acquired frame with respect to the top, or front, of the scanned object.

In this mode, a mechanical scanning system rotates the ultrasonic transducer about the scanned object. The ultrasound machine produces raw analog imagery **112** (RS170, video) while the mechanical scanning system produces a digital signal **114** containing the clockwise angle of the acquired frame. A computer system configured with a video frame grabber **116** is then used to digitize the ultrasonic raw frames **120** and record the digital signal containing the angle of the acquired frame. The ultrasonic raw frames and angles of acquired frames are then moved to the system's on-line storage **118**.

Image registration is shown in FIG. **16**. From on-line storage **118**, ultrasonic raw digital frames **120**, along with the transducer orientation and the center of rotation, are used in a image rotation operation **122**. Using the center of rotation and the transducer orientation, the ultrasonic frames are rotated about the center of rotation to the angle at which they were acquired. The resultant frames are spatially registered **124**.

The motion compensation process is shown in FIG. **17**. During the image acquisition phase, any motion of the scanned object will manifest itself by a blurring in the reconstructed cross section. It is desirable to sense and compensate for such motion. Depending on the angular increment of successive spatially registered frames **124** of the acquisition, the majority of the information results from the same geometry within the scanned object. Because of the common information from frame to frame, the data are highly correlated. A frame by frame image correlation **126** operation is applied resulting in correlation surfaces **128**. For each surface, a peak value (or greatest value) is detected **130**. The amount the peak is shifted from the center of the correlation surface gives rise to a motion-induced error estimate **132** (translation error). These motion-induced error estimates **132** are applied in the form of frame by frame translations **134** to produce motion compensated images **136**.

The incident rank value filtering process is shown in FIG. **18**. Within the motion compensated frames **136**, an individual pixel in the acquired geometry (within the scanned object) will be repeated in a number of frames. Rank value filtering is applied by sorting the pixels within the scanned object with identical coordinates across all frames **138**. The rank value images, sorted from minimum to maximum, are then stored **142**.

To produce the final composite image as shown in FIG. **19**, first the 90th percentile image is extracted **144** from the rank value images **140** (with 100th percentile being the greatest value). The 90th extracted image **144** is then threshold at the noise floor **146** of the ultrasound machine. This produces a binary image mask **148** with values of zero where the 90th percentile image was at or below the noise floor and one where the image was above the noise floor. An image is constructed from the pixels in the 100th percentile image that are in the 90th percentile mask image **150** (with value of one). The final composite image **152** that is formed is motion compensated and noise suppressed.

For tissue classification as shown in FIG. **9**, in the first order, the ultrasonic signal echoes of the human anatomy typically are described by either reflective (specular) or volumetric scattering characteristics. Any given tissue type such as bone, skin, blood vessels, muscle layers layers etc. is usually dominated by one of the characteristic types. Specular signal echoes usually diminish quickly with changes in angles of incidence when compared to scattering signal echoes.

A typical 2D horizontal mode process involves the following steps: 1) An angle of incidence, as compared to a signal echo value, is generated for each pixel within the scanned geometry; 2) The angular dependency of a given pixel within the scanned object is determined; and 3) a classifier recognizes the differences in tissue types based on their angular dependency. This is of particular importance when the above techniques are expanded to use in imaging abdominal cavities and other parts of the human anatomy.

FIG. **20** depicts the preferred 3D-vertical mode functional overview. In the vertical scanning mode, individual ultrasonic frames are acquired at a predetermined angular increment about the scanned object (in this case a lower human limb). A 3D volumetric reconstruction process is then applied which involves image acquisition **200**, image registration **202** and vertical reconstruction **204**.

The image acquisition process and apparatus is similar to the 2D system in FIG. **15**. However, the linear ultrasonic transducer is oriented perpendicular to the bottom of the tank and parallel to the scanned object. In this mode, the z axis corresponds to the individual ultrasonic transducer number, or height (increasing going up), the r axis corresponds to the radius from the center, or plumb line, of the tank, and theta corresponds to the clockwise angle of the acquired frame with respect to the top, or front, of the scanned object as observer from above the tank.

Referring to FIG. **15**, in this mode, a mechanical scanning system rotates the ultrasonic transducer about the scanned object. The ultrasound machine **110** produces raw analog imagery **112** (RS170, video) while the mechanical scanning system produces a digital signal containing the clockwise angle of the acquired frame. A computer system configured with a video frame grabber **116** is then used to digitize the ultrasonic raw frames and record the digital signal containing the angle of the acquired frame. The ultrasonic raw

frames and angles of acquired frames are then moved to the system's on-line storage **118**.

Image registration in the 3D mode is also similar to the 2D system as shown in FIG. **16**. From on-line storage **118**, the ultrasonic raw digital frames **120**, along with the transducer orientation and the center of rotation, are used in a image rotation operation **122**. Using the center of rotation and the transducer orientation, the ultrasonic frames are rotated about the center of rotation to the angle at which they were acquired. The resultant frames are spatially registered **124**.

The vertical reconstruction process is shown in FIG. **21**. Polar spatially registered frames **205** are presented in cylidrical coordinates (r,z,theta), but it is desirable to perform the reconstruction in Cartesian coordinates. A cylidrical to Cartesian transformation **206** is performed on the polar registered frames **205** producing a set of Cartesian planes, one corresponding for each individual z value in the acquired data. A bilinear interpolation scheme **208** is employed to produce a volumetric reconstruction **210** of the scanned object. For each point in the individual Cartesian planes, the four "surrounding" points from the acquired data are determined. A bilinear interpolation is performed to determine the value of the reconstructed point. The result is a set of planes of reconstructed cross sections of the scanned object, one corresponding to each z (height) value.

In operation skin recognition is performed by utilizing individual frames from a vertical acquisition which corresponds to a vertical slice through the limb. The skin is recognized by correlating a set of gabor filters against the individual frame. These filters are oriented −30,0 and +30 degrees, and the maximum response from the three filters for each point in the frame is recorded. The leading edge of the skin response is then determined by the brightest pixel observed for a given z value. The z,r and theta for that skin point are recorded. The process is repeated for all values and all acquired frames giving rise to a complete three dimensional description of the surface of the limb. This 3D description can be entered into a CAD package for potential fabrication of a 3D model of the scanned object (limb).

Once the image processing is completed, a digitized composite image can be utilized to fabricate a biomechanically correct prosthesis without reliance on an artisans experience. In the alternative, the digitized composite image can be displayed on a monitor, with the user manipulating the images for use as a diagnostic tool.

Long term clinical research will benefit from the present invention by being able to track the atrophy of residual limbs over time. There has been no method of accurately measuring this phenomenon because suitable data has not been acquired. The soft tissue atrophies with time, but the bone structure remains much the same. Locating the bone structure is necessary to track where the relative changes occur in the soft tissue. If the location of the bone structure can be determined using a non-contact ultrasound imager, then it will be possible to track patients over time using a low cost non-invasive procedure.

In addition to prosthesis fabrication, the present invention can be used as a diagnostic tool for hospital, clinic or field use to replace the present three dimensional diagnostic systems. Present three dimensional imaging systems to not have motion compensation which would discourage use in the field and their expense and physical size is prohibitive for such uses. A portable diagnostic imaging in forward echelon combat areas would greatly benefit army medics to determine the extent of injury and focus care on those wounded that have the highest probability of survival during the first hour of injury. In addition, the system could be made available to emergency medical technicians (EMTs) for civilian work. This information would provide high quality, high resolution, real time, 3-D ultrasound imaging necessary for diagnostics in the field that can be transmitted via telemetry to physicians for a diagnosis for the harmful affects of ionizing radiation that accompany the use of x-rays. The three major contributing factors in successful high resolution ultrasound imaging are optimizing, image acquisition producing redundant data, image processing and image display. The ultrasound system comprises a tracking arm, transducer and coupling medium built into a hand-held device for remote imaging.

The preferred ultrasonic diagnostic system is shown in FIG. **22**. Similar hardware and software components as described in the prosthesis fabrication embodiment are utilized in this embodiment. A six axis robotic arm **250** is utilized with requisite motors and encoders for position and angle data. Force sensor **252** is attached to robotic arm **250** to monitor and record force data. Ultrasound transducer **254** is attached to coupling **256** as shown. Cup **256** with seal assembly **258** is affixed to ultrasound transducer **254**. Water is pumped through cup **256** through water inlet **260** and out through outlet **262**.

Robotic arm **250** will help guide transducer **254** via passive or active path overlays to optimize image acquisition thereby maintaining perpendicularity to tissue, acoustic planes and controlling scan path trajectories. Data is processed for transmission with real time hardware. Telemetry transmission to the physician will allow them to further analyze the data or process the data for specific formatting such as two-dimensional cross-sections.

The key elements providing a high quality, portable ultrasound system includes the following: coupling medium paradigm, which include water baths, standoffs, low flow water streams as well as other well known coupling mediums; electro-mechanical arm which allows control of the image acquisition path and includes position and orientation feedback, transducer steering based on computer generated or master input path overlays; support for the transducer cable and water supply lines and counterbalancing; velocity aberration correction based on redundant data; software for path planning of the transducer; real time hardware and software for image acquisition and image processing; image compression hardware and software; telemetry; and image display (2D or 3D, in real time). A flowchart depicting this system is shown in FIG. **23**. Since ultrasound requires a coupling medium **300** in order to provide the transmission of an ultrasound signal, preferably water baths is used to act as the coupling agent. Other coupling agents such as stand off pads, gel pads or other known coupling agents in the art can be utilized. A low-flow, sterile, saline stream could be used a coupling medium as well as serving to provide sterile irrigation. Additionally, a water stream could be used to flow over non-penetrated skin surfaces without the need for a large source of water. However, flow rates, bubbles in the stream and fluid volume capacity must be considered. The most important component in obtaining high quality images is the optimization of image acquisition during scanning. A six degree of freedom mechanical arm **250** can be utilized to position and orient end mounted transducer on a standard ultrasound machine **254**, and also to provide near perpendicular orientation and path control for redundant data gathering mechanical arm **250** will enable transducer position and orientation data to be available for reconstruction of ultrasound images. This is superior to any non-contact based device because it provides precise information without concerns of obstructive line of sight or metallic interference

issues that limit non-contact devices. Mechanical arm **250** can he made compact and can incorporate counterbalancing devices allowing the transducer to be manipulating manually without difficulty. This will allow brakes and/or motors to be incorporated to kinematically control the path, thereby, optimizing the movement for near normal (perpendicular) orientation during motion. Sensors such as reflected light through the water path can he used upon perpendicularity for control adjustments (not shown). Alternatively, a master slave concept could be implemented to provide control of transducer positioning to remote surgeons/physicians. The master, controlled hy the home hase surgeon could be moved in the direction desired. The slave controlled hy the clinician, could be moved by the medic, with brakes or motors providing steering to overlay the desired path. Computer generated overlays can also be used to optimize the path and orientation of the transducer **254** over the body. Mechanical arm **250** will also provide support for cables, the water supply to the transducer as would a cahle tray. Rohotic simulation software, well known in the art, will be utilized to optimize mechanical arms **250** range motion for applications to various human anatomy. Path finding algorithms can also be employed that provided a model the scan path that should be taken in order to optimize the image acquisition.

The traditional method of image compression for fast transmission is to use a standard image compression algorithm such as JPEG or MPEG. Although these image compression schemes could be employed to optimize the data transmission, it would be beneficial to the physicians if "information triage" is performed prior to viewing. Information triage will take the form of image processing and segmentation to define the location of wound or shrapnel in combination with localized blood flow from Doppler in order to provide "improved" data to the physicians. By performing this image processing prior to viewing, a data compression ratio of over 1000:1 could potentially be accomplished for shrapnel and Doppler related data. Remaining data compression will be accomplished as described helow.

Velocity inhomogeneities cause roughly two kinds of distortion in ultrasound images. Small-scale inhomogeneities cause blurred and locally distorted images, and this effect can be reduced with phase aberration correction. The other kind of velocity inhomogeneities are large-scale, and this is a potentially more serious problem than the small-scale type, because they cannot be solved with phase aberration correction. Large-scale inhomogeneities occur when the tissues being imaged have significant differences in their speeds of sound. These differences in velocity cause distortion in the range coordinate (time axis) as well as distortion in the transverse coordinate due to bending or deflection of the rays representing the beam. Consider the example of two homogeneous cubes, one contained in the other. If the propagation velocities are different the image of the embedded cube will he distorted and the distortion will be dependent on transducer/imaging geometry and aspect angle. Thus, large-scale inhomogeneities cause geometric distortions in the image that will affect the accuracy of a medical diagnosis.

The prohlem of large-scale velocity inhomogeneities can be solved with redundant imaging. By combining many different views of the tissue from multiple directions, one can explicitly detect geometric distortions. Redundant imaging also has the effect of enhancing the image of smooth (specular) ohjects or interfaces. Small features can be tracked from view to view, looking for size changes attributable to velocity inhomogeneities. This incorporates optical speckle techniques as well as image processing techniques from digital signal processing, radar pattern recognition and morphology.

Phase-aberration correction techniques can he incorporated in the system. These techniques are strongly coupled to the hardware design and require processing of the signal from individual transducer elements. Methods for phase aberration correction can he applied to the linear, complex image that is available from some of the new ultrasound machines such as the General Electric LOGIQ 700.

The present invention can provide redundant imagery from multiple scanning geometries and form images exploiting that redundancy. From the redundant imagery, rudimentary angular reflection and scattering characteristics of various tissue types (skin, bone, muscle layers, etc.) may he extracted. Different tissue types will exhibit varying characteristics, and classification of tissue based on the reflection and scattering properties is possible. Mathematical and statistical foundations to autonomously classify various tissues types and techniques to display, manipulate and visualize the resulting two and three dimensional imagery can be made. The results should enhance the medical expert's ahility to provide high quality diagnostic information to the clinician in the field.

High quality diagnostic images from a field portable ultrasonic system should be provided to the rear echelon hospital in near real time to enhance a patient's survival during the first hour following injury.

The time latency associated with the image formation and processing techniques can he reduced by providing a system solution comhining Commercial Off-The-Shelf (COTS) hardware and system integration into a standard VME chassis. The image forming and processing techniques are hroken down into the basic image and signal processing operations required. The COTS hardware is then selected that maps these basic operations most efficiently. The hasic operations include but are not limited to image capture, translation, rotation, spatial filtering, time series filtering, convolution. The resultant system could he integrated into a Medical H for inclusion into an overall real time field portable ultrasonic system.

In the far forward battlefield scenario in which a medically equipped HMMMV would he use for initial medical diagnosis of injuries suffered from conflicts in proximity to the Forward Line Of Troops (FLOT), it may he desirahle to provide ultrasonic imagery via satellite link to rear echelon specialists up to hundreds of miles away (or even in the continental United States). Critical is the ultrasonic image compression technology that would allow ultrasonic imagery from two and three dimensional composites produced to he compressed while preserving image quality and integrity. Because of the expense involve in high bandwidth SATCOM links, it is desired to accomplish image transmission over a Ti data link with handwidth limitation of 1,500,000 bits per second. This could provide a much hroader area of coverage and flexibility of operation.

Ultrasonic and Synthetic Aperture Radar (SAR) imagery are very similar in nature and compression techniques that apply for SAR imagery should performs quite well for ultrasonic imagery. SAR is an army target recognition system. The techniques derived for compression of ultrasonic imagery can also be applied to storage and recall of imagery at rear echelon medical facilities or other central repositories for military medical records.

The most cost-effective and reliable method of transmitting the data from the forward echelon to the rear is to transmit the data in its raw format. This minimizes the

equipment and computational power required at the mobile site. In addition, all of the computational hardware is kept in a controlled environment—increasing the reliability of the overall system. The single computational unit can be used to process multiple input sources from multiple sites. Using data compression and approximately 10 frames per second video, the raw data transmission rate can be reduced to between 1–4 Mbits/second. This data transmission rate can be implemented using standard off-the-shelf RF telemetry hardware.

For far forward battlefield applications, portable, real-time hardware will be used to process data. However, in the rear echelon, access to an HPCC could be provided for processing power necessary for CPU-intensive activities such as real-time reconstruction of 3D images. These images could then be viewed locally and/or sent back to the front lines via telemetry for viewing.

EXAMPLES

(Industrial Applicability)

The invention is further illustrated by the following non-limiting examples.

Example 1

A first order model (simulation) of the ultrasonic imaging system was developed to evaluate the effects of refraction and scan geometry. The model was first developed in two dimensions and later extended to three dimensions. Geometrical optics were used to determine the image geometry. The acoustic beam is modeled as a Gaussian beam and the transducer is treated as a point receiving transducer. The limb being imaged is modeled as two materials, homogeneous flesh and homogenous bone.

Despite the simplicity, the model provides useful simulated images that illustrate some of the problems that are encountered in developing an ultrasonic imaging system. The model provides a useful estimate of image distortion and image brightness. The model includes effects due to refraction, acoustic impedance, attenuation, acoustic velocity, object geometry, and scan geometry.

The following describes the elements of the computer model. The description will be developed in terms of the two dimensional model. This is adequate since reflection/refraction are inherently planar calculations, that is, the calculations are carried out in the plane of incidence. Three dimensional aspects of the problem will be addressed as appropriate.

The ultrasonic sensor geometry modeled in computer software of a typical leg is shown in FIG. 24.

Ultrasonic transducer 22 is located at point A with its beam direction in the direction of the line AF. There are two types of scanning that are appropriate to model; a circular scan and a more general programmable scan.

The simplest and most common type scan is a circular scan. This type of scan is determined by picking a center point F in the limb data coordinates. Transducer 22 is then located at radius AF with the beam oriented along the line AF. Transducer 22 is then rotated through 360 degrees about point F to generate the image. Scan increments are determined by the resolution and image definition requirements. The point F is a variable in the program.

The programmable scan is an option that allows the transducer position and orientation to be programmed to follow an arbitrary path. One scan geometry of interest is a linear scan where transducer 22 is moved along a line with the angle held constant. More general scans can be made up from linear scans by summing linear scans with a discrete variation in the angle variable (parameter). Another scan geometry of interest is one in which transducer 22 is scanned over a range of angles at each position along a prescribed curve.

The angles of reflection and refraction are calculated using the equations

$$\theta_i = \theta_r \tag{1}$$

$$\frac{\sin\theta_i}{\sin\theta_r} = \frac{c_i}{c_r} \tag{2}$$

where the subscripts refer to the incident and reflected rays and the c's are the acoustic velocities in the corresponding medium. Distances such as AB and BC are calculated using an algorithm for computing the intersection of rays with the limb data skin and bone surfaces. The relative acoustic intensity of reflected and refracted rays are calculated using the equations

$$\alpha_r = \left[\frac{\rho_2 c_2 - \rho_1 \sqrt{c_1^2 - c_1^2 \sin^2\theta_1}}{\rho_2 c_2 + \rho_1 \sqrt{c_1^2 - c_2^2 \sin^2\theta_1}} \right]^2 \tag{3}$$

$$\alpha_t = \frac{4 \rho_1 c_1 \rho_2 c_2 \cos\theta_1 \sqrt{1 - (c_2/c_1)^2 \sin^2\theta_1}}{\left(\rho_2 c_2 \cos\theta_1 + \rho_1 c_1 \sqrt{1 - (c_2/c_1)^2 \sin^2\theta_1}\right)^2} \tag{4}$$

and

$$\alpha_r + \alpha_t = 1 \tag{5}$$

In these equations, the numerical subscripts are ordered in the direction of the acoustic wave (ray) being considered and the ρ's are the corresponding material densities.

The relative intensity of the acoustic beam is represented in angle as a Gaussian beam given by

$$\beta(\phi) = \frac{I(\phi)}{I(\phi)} = \exp[-(\sin\phi/\sin\phi_0)^2] \tag{6}$$

where

$$-\frac{\pi}{2} < \phi < \frac{\pi}{2} \tag{7}$$

$$\sin\phi_0 = \frac{2}{\pi} \cdot \frac{\lambda}{d_0}$$

In equation, 7, λ is the acoustic wavelength and d_0 is the beam width at the beam waist (smallest width of beam). The beam width is usually taken to be the effective width of the transducer. However, the beam divergence angle can be empirically adjusted to account for scattering or receiver aperture width.

Generally, acoustic beams decrease in intensity as they propagate due to absorption and scattering. In the model beam attenuation is incorporated as an exponential decrease by the equation

$$I(x) = I(O)\exp[-\eta x] \tag{8}$$

where n is the effective absorption coefficient. In its present form, the model does not include a decrease in intensity due to the divergence of the beam.

The relative image brightness determined by tracking the acoustic rays as they bounce off the various surfaces taking into account the loss of intensity due to reflection/transmission and attenuation as appropriate. The computation is illustrated for a few points in FIG. 24 by the following.

The relative image brightness of point B (relative to the transmitted intensity) in FIG. 24 is given by

$$\frac{I_r(B)}{I_t} = \alpha_r\beta(2\theta_i) \tag{9}$$

The factor of 2 in the argument of β is due to the fact that the angle between the reflected ray and the ray returned to the transducer is twice the incident angle.

The relative brightness of the return from point C is given by

$$\frac{I_r(C)}{I_t} = \alpha_t\alpha_t\beta(2\theta_B) \tag{10}$$

where the prime denotes the transmission in the opposite direction. One then continues in this manner, keeping track of the rays as they intersect the various surfaces. Attenuation is accounted for using equation 8 and the computed distance between consecutive reflection points.

The image of point B is located a distance

$$AB' = \frac{V_R}{V_{AB}} \cdot AB \tag{11}$$

from point A along line AF. V_R is the reference acoustic wave velocity. Similarly, the image point location of point C is given by the distance.

$$AC' = \frac{V_R}{V_{AB}} \cdot AB + \frac{V_R}{V_{AB}} \cdot BC \tag{12}$$

again, along line AF.

The two dimensional ultrasound simulation package is a C/C++ program that applies ultrasonic computation and image generation mathematics to mock ultrasound beams and predetermined tank and body part such as leg geometries. The calculations are applicable to a plane containing both the incident and scattered beam and a two dimensional leg model. A model is created of the acoustic properties of both the ultrasound beam and the materials it travels through with sufficient fidelity to predict the salient characteristics of the ultrasound image. The basic equations used in the simulation are given above.

The algorithm requires input from leg and scan tub geometries along with the ultrasound beam parameters such as where the scans originate from, the direction they travel, and the strength of the beam.

It also requires the acoustic properties of the materials in each region (i.e., water, muscle, bone, etc.).

This is a collection of C and C++ programs with a Devguide based user interface. The output displays are done using Gnuplot windows. Beams are traced using recursive calls on reflected and transmitted components of rays as they intersect surfaces in the simulation. The return is always assumed along the incident beam path.

A typical menu for the two dimensional simulator with details for each of the field/buttons are as follows:

Coordinates of the center of the leg: This field allows the user to specify the X,Y coordinates of the center of the object being scanned. The coordinate parameters allow the object to be placed at various locations in the tank during the simulated scan.

Nominal speed of sound (cm/sec): This field allows the user to declare the nominal speed of sound in water.

Frequency in Hz: This field allows the user to specify the frequency of the simulated ultrasound beam.

Lower limit of return signal: This field sets the lower limit of signal strength for return beams to be detectable. Initial transmitted power: This field sets the power of the initial beam transmission.

Focus beam radius (cm): This field sets the radius of the beam width at the beam waist.

Max time for return signals: This field sets the maximum duration of time allowable for return signals to be detected.

Number of sensors in scan: This field sets the number of discrete locations (or stops) from which scans are done. They are concentrically located around the "tub".

Create scan path: This field initiates the creation and execution of the simulation using the specified parameters, generating a file containing the output results.

Display plot: This field causes one of two types of display to appear. If simulated data, or CT data, have been chosen on "Data type," a Gnuplot window displays the results of the simulation run. If "three dimensional view" is selected, it causes a three dimensional grid display of the stored CT geometry but without scan data. Data type:

- Simulated data—selects simulated data for the scan—either a leg model or circles.
- CT data—selects leg geometries obtained from actual CT scans for the simulation. The user may choose any of the available CT cuts.
- Three Dimensional View—allows display of a three dimensional view of the "CT data."

Model type: When "simulated data" is selected under "Data type", "Model Type" allows you to select either a leg model or circles for the scanned object.

Number of sweep scans: This field selects the number of actual angular scans taken at each of the stops in the scan (at each of the discrete locations of the scanner).

Sweep angle: The angle over which the "number of sweep scans" is uniformly distributed at each of the discrete scan locations.

FIGS. 25–29 are examples of the simulation. FIG. 25 is an example of simulated leg geometry with 50 sensors, 1 scan per sensor using simulated leg geometries. FIG. 26 shows 50 sensors, 1 scan per sensor for a circle. FIG. 27 is a simulated offset center circle. FIG. 28 is an actual CT scan. FIG. 29 shows 5 scans at each of 30 sensors.

The three dimensional model uses logic similar to the two dimensional model, but it extends into three dimensions. The differences include scan beams that have X,Y,Z components to both their origin and their direction. Points of intersection occur between three dimensional vectors and planes, as opposed to lines contained in the Z=0 plane, and, therefore, may have components in the Z direction. Finding the points of intersection is much more involved, and, consequently, the run time is much greater. Because the time constraints, this algorithm has only been implemented in batch mode with precalculated fixed scan parameters. The data input for the three dimensional mode contain:

- a file containing the parameters of the scan beams which includes the origin and direction (in three dimensional space) as well as the beam strength, created by a separate algorithm; and
- separate files for tank and leg geometries which define the three dimensional surfaces of the objects.

The three dimensional simulation is a batch mode C program which uses three dimensional vector geometry to trace the beams with recursive calls on the reflected and transmitted components of rays that result from intersections with object surfaces. Rays are terminated when their power has dropped below a predetermined threshold, or are absorbed by the tank wall. Return signals are calculated at each intersection; again, assume a return along the incident beam path. Output is a file of three dimensional points.

FIG. 30 shows the output points displayed as small black cubes with the three dimensional rendering of the skin and bone surfaces used in the scan.

Because the ultrasound machine provides a planar image that represents a cross-sectional view of the object, an additional spatial dimension must be imparted to the transducer in order to generate a three dimensional, volumetric image. The mechanical scanner provides the additional scanning motion necessary to develop the third dimension of the image. The scanner is designed based on the results of the computer model which concluded that a circular scan around a BK limb is sufficient for providing skin and partial bone surface information.

Example II

The 3D ultrasound imaging system was tested on 10 unilateral below-the-knee amputees at the Health Science Center in San Antonio. Image data was acquired from both the sound limb and the residual limb. The imaging system was operated in both volumetric and planar formats. An x-ray CT scan was performed on each amputee for comparison. Qualitative and quantative studies were performed to compare CT and ultrasound data sets. Results of the test indicate beneficial use of ultrasound to generate databases for fabrication of prostheses at a lower cost and with better initial fit as compared to manually fabricated prostheses. In addition, qualitative results indicate that planar images represent substantial improvements over standard ultrasound images and that they could serve as improved diagnostic images.

In general, the human subjects placed their legs within the water bath while holding onto the support railing. The ultrasound gains were set for optimum image quality. Images were stored on the computer for later retrieval and manipulation.

These ten subjects made up of 5 women and 5 men provided databases for establishing the repeatability and quality of the ultrasound scanning system. Each subject was scanned using the vertical and horizontal oriented transducer. Each leg on the subject was scanned to double the effective data set. The system was fine-tuned based on the results of the scans.

After each data set was obtained, the images were processed through the visualization software used to generate a composite image. For the men in the study, leg hair posed a problem for image acquisition. Leg hair tends to trap air bubbles and turned to blur the definition of the skin surface. The volunteers opted to wear women's leg hosiery to keep the leg hair close to the skin rather than shaving the leg. Movement, high reflection at the surface of the sock, and poor centering were corrected for. Modifications in the scan procedure were made based on the "lessons learned" during the scans as well as improvements to the visualization software. The result of this exercise was an improved image acquisition procedure and improved visualization software.

Algorithms were developed to "edge" accurately the two dimensional ultrasound cross-section images reconstructed from the vertical scans and the two dimensional CT cross sections. See FIGS. 31 and 32 for examples of the ultrasound and CT images.

The outlines obtained from the ultrasound process can then be used to produce three dimensional models of the leg. The images are first brought to a threshold to eliminate noise in and around the leg cross section. The edging algorithm starts from a "first" valid point, usually chosen by the user. From that point, the algorithm searches for the next point on the edge within a bounding box of specified size. The initial perpendicular to the surface at that point is assigned at 180. Vectors are defined from the first point to each point in the bounding box. The next valid point on the edge is chosen as the one with the smallest vector angle with respect to the perpendicular. Continuing around the leg, angles are computed to the points contained in the bounding box with respect to a perpendicular to the edge created by the last two valid points. The next point chosen on the edge is the one with the smallest angle. The process continues around the leg until the first point on the edge is contained within the bounding box, indicating the completion of the edge. See FIG. 33 for an example of a resulting edge from a CT scan.

This edging algorithm is used for edging the CT scans, including skin, tibia, and fibula, all of which must be done separately. The algorithm is also used for edging the ultrasound skin image, but cannot be used for the bones in the ultrasound images. The ultrasound images are somewhat coarse, and the bones are "incomplete" on the inside of the leg where the ultrasound has been reflected and attenuated by the bone, shading the back portion of the bone. Therefore the only valid bone data on the ultrasound scans is that near the surface or skin of the leg. Instead of using the automated edging algorithm, the bone images must be edged by "placing and re-sizing" templates of the bones on each cross-section. The marker affixed to the skin is visible at the upper right edge of the image in FIG. 31.

A graphical user interface (GUI) was designed which allows the user to compare qualitatively images obtained with the ultrasound platform to the CT images obtained. The interface was written for use on a Silicon Graphics (SGI) machine, using "Forms" (SGI software for creating windows, buttons and other user interfaces), Graphics Language, and C programming.

With the GUI, the user can load a series of images for a particular patient: ultrasound, CT, and edge points created by the edging routine. See FIG. 31 for an example of an image viewed using the GUI. The user may "browse" through the series of ultrasound or CT cross-sections image by image. In order to make a comparison, the user may, for instance, display an ultrasound image at a particular position on the leg. Next, the user can display the CT edge image, generated from the corresponding CT scan taken at approximately the same position on the patient's leg, overlaid in red on top of the ultrasound image. Features such as "click and drag", rotation, mirror, and scale are incorporated in the edge image display in order to properly line it up with the corresponding ultrasound image. Once it has been positioned for the "best fit", a visual comparison can be made of the proportions and positions of the features in the leg.

Because of problems present with leg deformation in the CT scans (due to parts of the leg being supported during scanning), making comparisons between the ultrasound and CT scans is difficult. Two dimensional comparisons are greatly affected by any deformation since displaced tissue can cause cross-sections taken at the same position on the leg to look very different. It was decided that three dimensional volumetric comparison methods would give more accurate results than two dimensional scan-by-scan comparisons. The theory behind this idea was that if any deformation occurred at a point on the leg, the tissue would be displaced a small distance away from its usual position. By examining the entire volume of the leg model, any individual tissue displacements should not affect the overall volume calculation.

Another GUI was created which displays three dimensional wire frame and solid polygon models generated from both ultrasound and CT images. See FIGS. 34 and 35 for an example of a comparison of ultrasound and CT three dimen-

sional solid models. Edge points from the ultrasound and CT images for the specified patient are loaded by the application. The user can rotate and translate the models in order to facilitate viewing or to align the models for comparisons. The application contains a routine developed to iteratively orient the corresponding CT and ultrasound volumetric models by rotating and translating for the best geometric fit. Three dimensional point sets from the ultrasound data are registered with corresponding three dimensional point sets from CT scans. The two models can be registered by their entire volumes or only their intersecting length portion. If the ultrasound and CT models are separated initially, they should be registered based on their entire volumes since there is no intersection. If, however, the models have been approximately registered by the user beforehand, using the registration based on their intersection will refine the pose of the ultrasound point sets to find the best registration. See FIGS. 36 and 37 for examples of the ultrasound and CT models after registration.

The point sets are registered based on Besl and McKay's (Besl & McKay, 1992) "iterative closest point" (ICP) algorithm. This algorithm searches for the minimum mean-squared distance between the two point sets. For each point in the moveable point set (ultrasound in this case), it finds the closest point in the stationary point set (in this case CT). The ICP then computes a transformation matrix to minimize the distances between the matched points. The moveable points are moved according to this computed transform. This process of matching and moving is repeated until the mean-squared distance cannot be reduced any further.

Once the models are properly registered, a quantitative volumetric comparison can be made. In order to accurately compare the volumes of the ultrasound and CT three dimensional models, only the intersecting length portions of the two volumes are considered. This process is necessary because the CT volumes often represent a much longer portion of the leg than the ultrasound data. The volumes of the two models are then calculated, and a percent difference value is given.

The preceding examples can be repeated with similar success by substituting the generically or specifically described reactants and/or operating conditions of this invention for those used in the preceding examples.

Although the invention has been described in detail with particular reference to these preferred embodiments, other embodiments can achieve the same results. Variations and modifications of the present invention will be obvious to those skilled in the art and it is intended to cover in the appended claims all such modifications and equivalents. The entire disclosures of all references, applications, patents, and publications cited above, and of the corresponding applications, are hereby incorporated by reference.

What is claimed is:

1. An apparatus for generating a video presentation of ultrasound images of an object, the apparatus comprising:

- a multielement ultrasound transducer that radiates ultrasound energy in a first plane;
- means to move the transducer about the object in a second plane;
- means for acquiring at least one plurality of partially redundant ultrasound images in the first plane in scan increments of the object;
- means for converting said acquired images into a selected format;
- means for storing said converted images; and
- means for registering said converted images to generate a composite image of the object.

2. The invention of claim 1 wherein said at least one ultrasound transducer comprises a two dimensional array of ultrasound transducers.

3. The invention of claim 1 wherein said means for acquiring at least one plurality of partially redundant ultrasound images in the first plane comprises a means for acquiring data from known orientations and positions.

4. The invention of claim 3 wherein said orientations comprise angles from a home orientation.

5. The invention of claim 3 wherein said means for acquiring data from known orientations and positions comprises feedback means for optimizing a next scan.

6. The invention of claim 5 wherein said feedback means comprises a means for reorienting said at least one ultrasound transducer based on a previous scan's signal quality.

7. The invention of claim 3 wherein said means for acquiring data from known orientations and positions comprises a filter means for acquired data reduction.

8. The invention of claim 7 wherein said filter means comprises rank value filtering.

9. The invention of claim 3 wherein said means for acquiring data from known orientations and positions comprises a position transducer.

10. The invention of claim 9 wherein said position transducer comprises a member selected from the group of encoders, potentiometers, LVDT'S, resolvers, magnetic encoders, and inductosync apparatuses.

11. The invention of claim 10 further comprising a tachometer.

12. The invention of claim 11 wherein said means for registering further comprises a means for object motion compensation.

13. The invention of claim 3 wherein said means for acquiring data from known orientations and positions comprises means for determining coordinates for selected targets within the object from said converted images.

14. The invention of claim 1 wherein said partially redundant ultrasound images comprise vertical partially redundant images.

15. The invention of claim 1 wherein said partially redundant images comprise horizontal partially redundant images.

16. The invention of claim 1 wherein said partially redundant images comprise partially redundant images in any known angle between horizontal and vertical.

17. The invention of claim 1 wherein said scan increments comprise surface normal optimization.

18. The invention of claim 17 wherein said means for object motion compensation comprises correlating partially redundant image data.

19. The invention of claim 1 wherein said scan increments comprise said composite image with an optimized intensity of predetermined anatomical features of the object.

20. The invention of claim 1 wherein said means for registering comprises a transformation matrix means for realignment of converted image data relative to home position orientation.

21. A method of generating a video presentation of ultrasound images of an object, the method comprising the steps of:

- a) providing a multielement ultrasound transducer radiating in a first plane;
- b) moving the transducer about the object in a second plane;
- c) acquiring at least one plurality of partially redundant ultrasound images in a same plane in scan increments of the object;

d) converting said acquired images into a selected format;

e) storing said converted images; and

f) registering said converted images to generate a composite image of the object.

22. The method of claim 21 wherein the step of providing at least one ultrasound transducer comprises providing a two dimensional array of ultrasound transducers.

23. The method of claim 21 wherein the step of acquiring at least one plurality of ultrasound images comprises acquiring data from known orientations and positions.

24. The method of claim 23 wherein the step of acquiring data from known orientations comprises acquiring angle data from a home orientation.

25. The method of claim 23 wherein the step of acquiring data from known orientations and positions comprises optimizing a next scan with feedback from a prior scan.

26. The method of claim 25 wherein the feedback comprises reorienting the at least one transducer based on a previous scan's signal quality.

27. The method of claim 23 wherein the step of acquiring data from known orientations and positions comprises providing a filter for acquired data reduction.

28. The method of claim 27 wherein the filter comprises rank value filtering.

29. The method of claim 23 wherein the step of acquiring data from known orientations and positions comprises providing a position transducer.

30. The method of claim 29 wherein the step of providing a position transducer comprises providing a member selected from the group of encoders, potentiometers, LVDT's, resolvers, magnetic encoders, and inductosync apparatuses.

31. The method of claim 29 further comprising the step of providing a tachometer.

32. The method of claim 23 wherein the step of acquiring data from known orientations and positions comprises determining coordinates for selected targets within the object from the converted images.

33. The method of claim 21 wherein the step of acquiring at least one plurality of partially redundant images comprises acquiring at least one plurality of partially redundant vertical images.

34. The method of claim 21 wherein the step of acquiring at least one plurality of partially redundant images comprises acquiring at least one plurality of partially redundant horizontal images.

35. The method of claim 21 wherein the step of acquiring at least one plurality of partially redundant images comprises acquiring at least one plurality of partially redundant images in any known angle between horizontal and vertical.

36. The method of claim 21 wherein the step of acquiring at least one plurality of partially redundant ultrasound images in the first plane in scan increments comprise optimizing surface normal.

37. The method of claim 21 wherein the step of acquiring at least one plurality of partially redundant ultrasound images in the first plane in scan increments comprises optimizing the intensity of predetermined anatomical features of the object from the composite image.

38. The method of claim 21 wherein the step of registering comprises realigning the converted image data relative to home position orientation with a transformation matrix.

39. The method of claim 38 wherein the step of registering further comprises compensating for object motion.

40. The method of claim 39 wherein the step of compensating for object motion comprises correlating partially redundant image data.

* * * * *

US005982951A

United States Patent [19]

Katayama et al.

[11] Patent Number: 5,982,951

[45] Date of Patent: Nov. 9, 1999

[54] APPARATUS AND METHOD FOR COMBINING A PLURALITY OF IMAGES

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[73] Assignee: Canon Kabushiki Kaisha, Tokyo, Japan

[21] Appl. No.: 08/862,753

[22] Filed: May 23, 1997

[30] Foreign Application Priority Data

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[51] Int. Cl.[6] G06K 9/36

[52] U.S. Cl. 382/284; 382/276; 358/450; 358/540; 348/584

[58] Field of Search 382/284, 283, 382/276, 274; 345/115–118, 435, 438, 113; 348/47, 584–601; 358/501, 540, 466, 456, 450

[56] References Cited

U.S. PATENT DOCUMENTS

5,140,647	8/1992	Ise et al.	382/284
5,185,808	2/1993	Cok	382/284
5,287,418	2/1994	Kishida	358/466
5,581,377	12/1996	Shimizu et al.	358/540
5,646,679	7/1997	Yano et al.	348/47
5,680,150	10/1997	Shimizu et al.	345/438
5,721,624	2/1998	Kumashiro et al.	358/450

FOREIGN PATENT DOCUMENTS

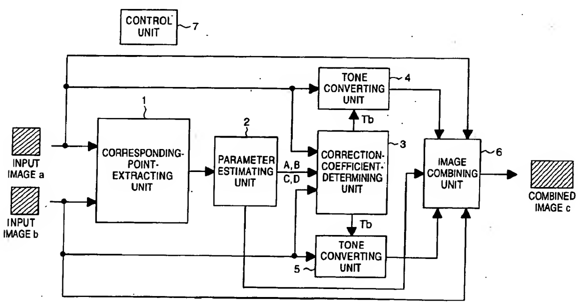
7-115534	5/1995	Japan	H04N 1/387
2130838	6/1984	United Kingdom	H04N 1/40

Primary Examiner—Leo H. Boudreau
Assistant Examiner—Ishrat Sherali
Attorney, Agent, or Firm—Morgan & Finnegan LLP

[57] ABSTRACT

An image combine apparatus for combining a plurality of images to generate a panoramic image. The image combine apparatus identifies an overlapping region of two inputted images and determines a boundary of the two images. The image combine apparatus then sets a tone correction area having a predetermined width such that the boundary of the two images is the center of the area, and performs tone correction within the area. The image combine apparatus performs linear tone correction in accordance with a distance between a pixel and the boundary. In the neighbor of the boundary of the two images within the tone correction area, density of the image gradually changes, thus a combined image whose boundary of the two images is inconspicuous is obtained.

18 Claims, 20 Drawing Sheets



1000

FIG. 1

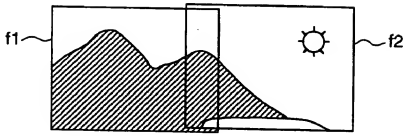


FIG. 2A

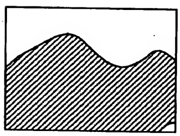


FIG. 2B

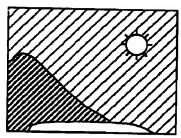


FIG. 3

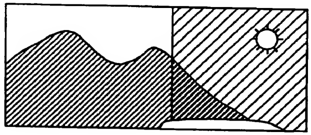


FIG. 4

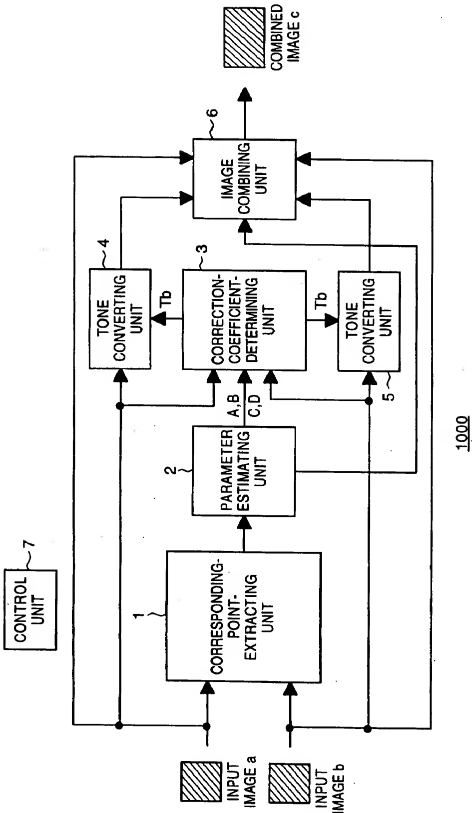

COMBINED IMAGE c
6
IMAGE COMBINING UNIT
4
TONE CONVERTING UNIT
Tb
3
CORRECTION-COEFFICIENT-DETERMINING UNIT
Tb
TONE CONVERTING UNIT
5
A,B
C,D
2
PARAMETER ESTIMATING UNIT
7
CONTROL UNIT
1
CORRESPONDING-POINT-EXTRACTING UNIT
1000
INPUT IMAGE a
INPUT IMAGE b

FIG. 5

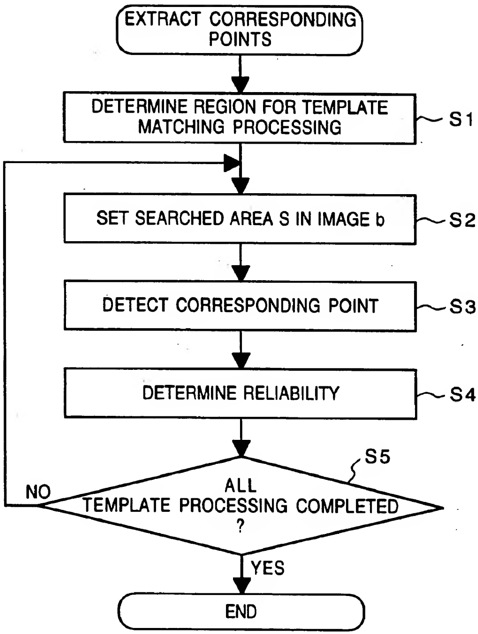

EXTRACT CORRESPONDING POINTS
DETERMINE REGION FOR TEMPLATE MATCHING PROCESSING
S1
SET SEARCHED AREA S IN IMAGE b
S2
DETECT CORRESPONDING POINT
S3
DETERMINE RELIABILITY
S4
S5
ALL TEMPLATE PROCESSING COMPLETED ?
NO
YES
END

FIG. 6A

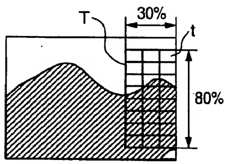


FIG. 6B

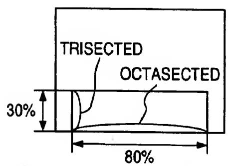


FIG. 7A

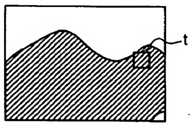


FIG. 7B

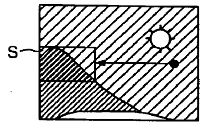


FIG. 8

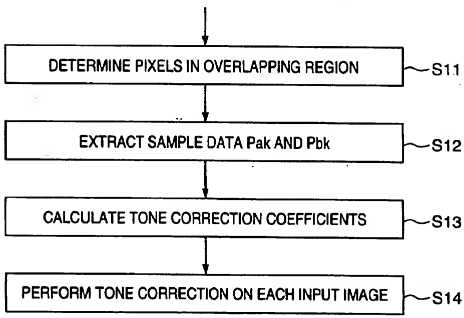


FIG. 9

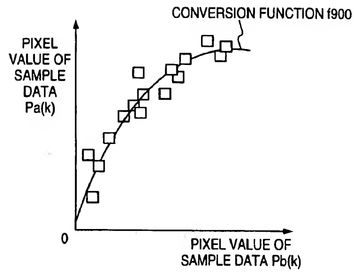


FIG. 10

910

PIXEL VALUE Pb OF IMAGE b	PIXEL VALUE f(Pb) AFTER TONE CONVERSION
0	5
1	7
2	12
252	245
253	246
254	247
255	248

FIG. 11

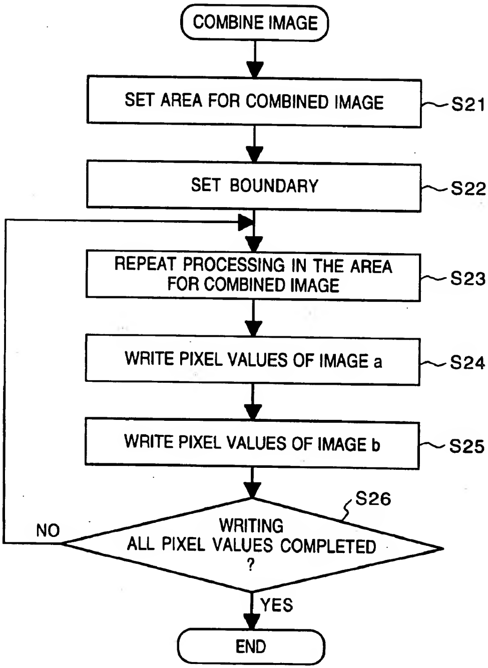

COMBINE IMAGE
SET AREA FOR COMBINED IMAGE
S21
SET BOUNDARY
S22
REPEAT PROCESSING IN THE AREA FOR COMBINED IMAGE
S23
WRITE PIXEL VALUES OF IMAGE a
S24
WRITE PIXEL VALUES OF IMAGE b
S25
S26
WRITING ALL PIXEL VALUES COMPLETED ?
NO
YES
END

FIG. 12

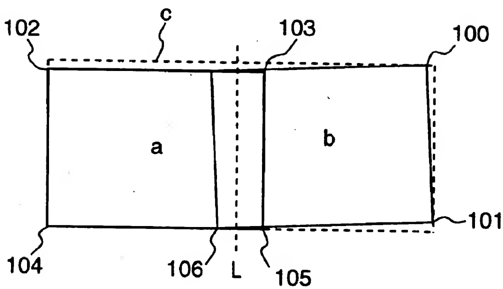


FIG. 13

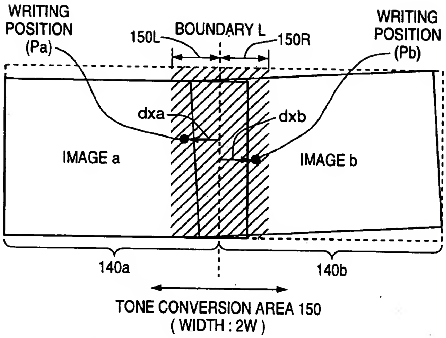

WRITING POSITION (Pa)
150L
BOUNDARY L
150R
WRITING POSITION (Pb)
dxa
dxb
IMAGE a
IMAGE b
140a
140b
TONE CONVERSION AREA 150
(WIDTH : 2W)

FIG. 14

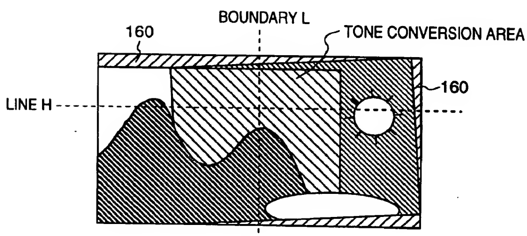

BOUNDARY L
160
TONE CONVERSION AREA
LINE H
160

FIG. 15

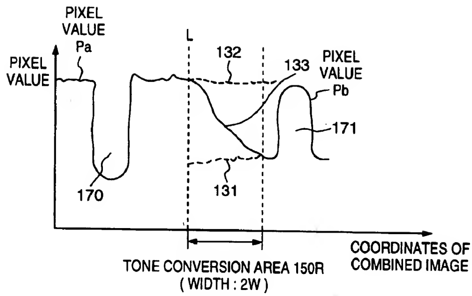
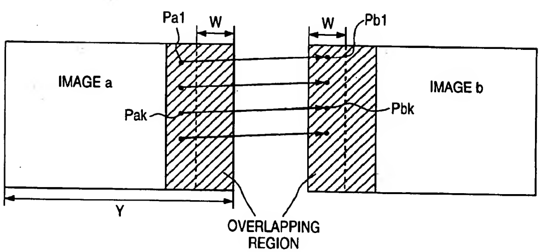
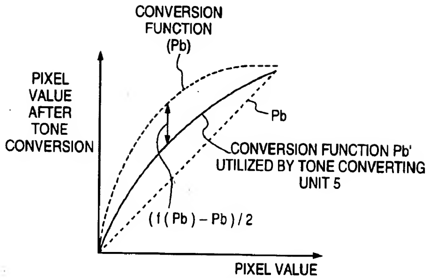


FIG. 16



FIRST MODIFIED EMBODIMENT

FIG. 17



SECOND MODIFIED EMBODIMENT

FIG. 18

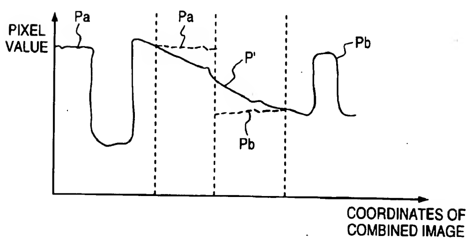


FIG. 19

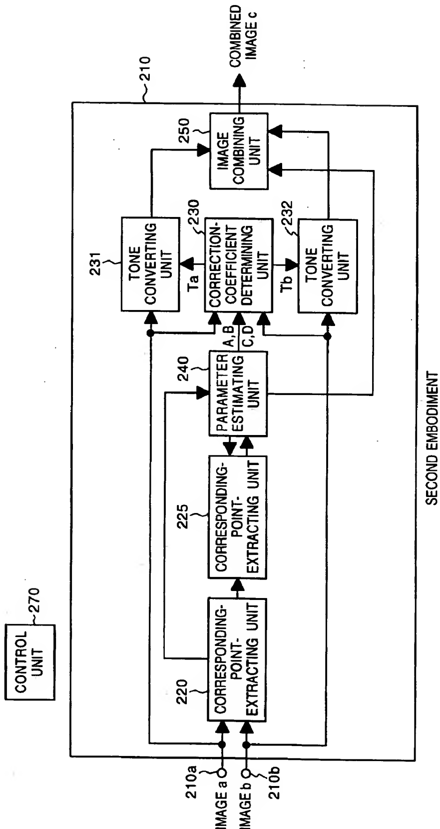

COMBINED IMAGE c
210
250
IMAGE COMBINING UNIT
231
TONE CONVERTING UNIT
230
CORRECTION-COEFFICIENT DETERMINING UNIT
232
TONE CONVERTING UNIT
Ta
Tb
A, B
C, D
240
PARAMETER ESTIMATING UNIT
225
CORRESPONDING-POINT-EXTRACTING UNIT
220
CORRESPONDING-POINT-EXTRACTING UNIT
270
CONTROL UNIT
SECOND EMBODIMENT
IMAGE a
210a
IMAGE b
210b

FIG. 20

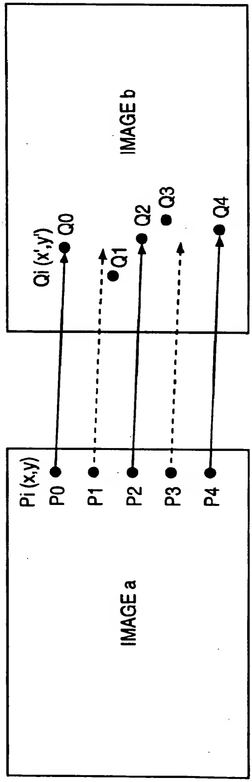


FIG. 21

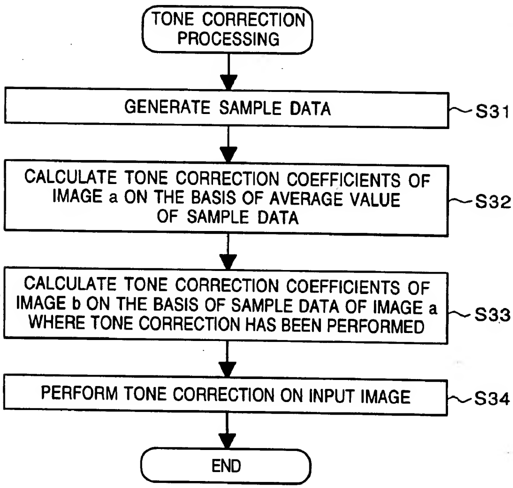

TONE CORRECTION PROCESSING
GENERATE SAMPLE DATA
S31
CALCULATE TONE CORRECTION COEFFICIENTS OF IMAGE a ON THE BASIS OF AVERAGE VALUE OF SAMPLE DATA
S32
CALCULATE TONE CORRECTION COEFFICIENTS OF IMAGE b ON THE BASIS OF SAMPLE DATA OF IMAGE a WHERE TONE CORRECTION HAS BEEN PERFORMED
S33
PERFORM TONE CORRECTION ON INPUT IMAGE
S34
END

FIG. 22

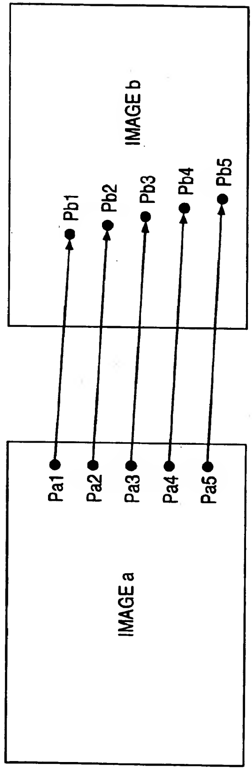


FIG. 23A

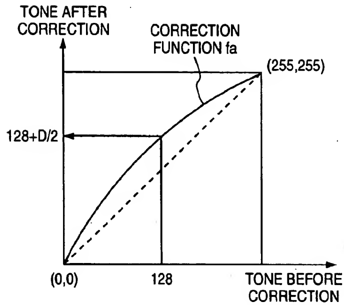


FIG. 23B

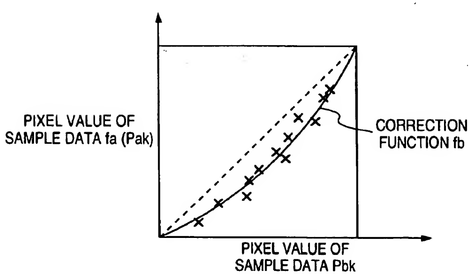


FIG. 24

PIXEL VALUE OF IMAGE b	PIXEL VALUE AFTER TONE CONVERSION
0	5
1	7
2	12
252	245
253	246
254	247
255	248

FIG. 25A

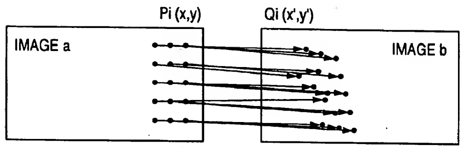


FIG. 25B

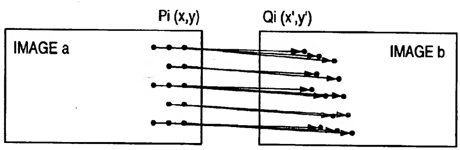


FIG. 25C

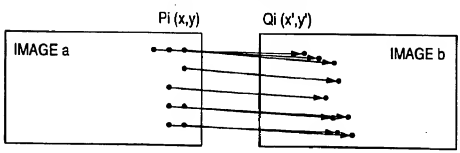


FIG. 26A

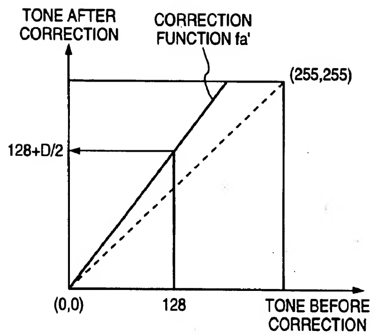


FIG. 26B

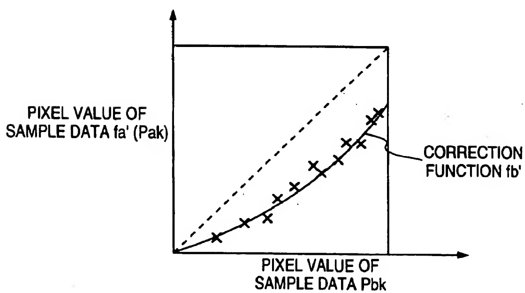
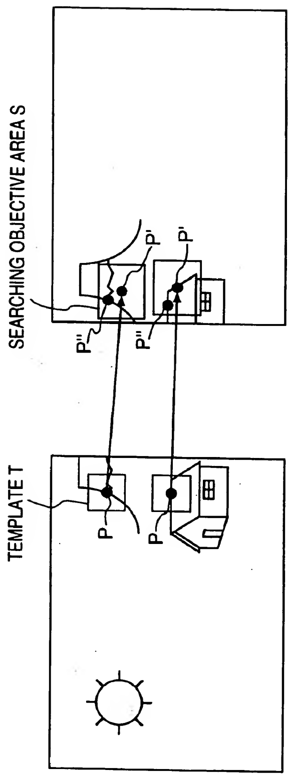


FIG. 27



APPARATUS AND METHOD FOR COMBINING A PLURALITY OF IMAGES

BACKGROUND OF THE INVENTION

The present invention relates to an apparatus and a method for combining images, and more particularly, to an image combining apparatus and method thereof for combining a plurality of images partially including an overlapping region having the same image, to generate one panoramic image having a wide angle of view.

According to the conventional method of generating a panoramic image having a wide angle of view by combining a plurality of images partially having an overlapping region of the same image, two images are combined on a plane by geometrical transformation such as Affin transformation or the like to coincide coordinates values of two corresponding points, which are extracted from the overlapping regions having the same image but having different coordinates values.

However, in a case where conditions, particularly exposure conditions, of photographing the plurality of images are different for each image due to some factors of a photographing subject, even if the two images are combined precisely with the corresponding points being coincided according to the conventional method, the boundary of the images would have a conspicuous line due to the difference in lightness of the images.

The disadvantage of the conventional image combine technique is explained with reference to FIGS. **1**, **2A**, **2B** and **3**.

It is assumed herein that an image of a subject shown in FIG. **1** is picked up by an electronic still camera or the like, taking two frames (frame fl and frame f2) of photographs. Since the subject picked up by the frame fl has a dark atmosphere as a whole, the camera corrects an exposure amount at the time of image pick-up such that the dark portion would be lighter. As a result, an image shown in FIG. **2A** is obtained. Since the subject picked up by the frame f2 has a light atmosphere as a whole, the camera corrects an exposure amount at the time of image pick-up such that the light portion would be darker. As a result, an image shown in FIG. 2B is obtained. Accordingly, even if the two inputted images (images in FIGS. **1A** and **1B**) are combined precisely, the combined image shown in FIG. **3** would have a conspicuous line due to the difference in lightness.

SUMMARY OF THE INVENTION

The present invention has been made in consideration of the above situation, and has as its object to provide an image combining apparatus and method capable of combining images in a manner such that the boundary of the images is inconspicuous even in a case where exposure conditions are different for each inputted image.

Another object of the present invention is to provide an image combining apparatus and method which can generate a combined image whose boundary of the images is inconspicuous, by discriminating and identifying an overlapping region having the same image in two inputted images, and correcting tones of either or both of the inputted images in accordance with difference in tone density between the two inputted images.

Still another object of the present invention is to provide an image combining apparatus and method which can generate a combined image whose boundary of the images is inconspicuous, by performing tone correction particularly in the neighbor of the boundary.

Still annther object of the present invention is to provide an image combining apparatus and method which can generate a combined image whose boundary of the images is inconspicuous, by performing tone correction on pixels in the neighbor of the boundary in the overlapping region, in accordance with how far the pixel of interest is from the boundary.

Still another object of the present invention is to provide an image combining apparatus and method which can generate a combined image whose boundary of the images is inconspicuous, by removing erroneously recognized corresponding points from a set of corresponding points which have been detected to identify the overlapping region of the images, and by determining parameters of tone correction on the basis of the set of corresponding points from which the erroneous corresponding points are removed, thereby increasing precision of tone correction.

According to a preferred embodiment of the present invention, since a coefficient of weighting is set in accordance with how far the pixel of interest is from the boundary of the images, it is possible to obtain a combined image on which smooth tone conversion has been performed.

According to a preferred embodiment of the present invention, since the tone conversion is performed only within a predetermined area, the processing time can be reduced, moreover it is possible to obtain a combined image which is consistent with the image before conversion.

According to a preferred embodiment of the present invention, since an area to be subjected to tone conversion is determined in accordance with the image in the overlapping region of the inputted images, tone correction and combine processing appropriate for the image are performed, thus possible to obtain a high-quality combined image.

According to a preferred embodiment of the present invention, since an area to be subjected to tone conversion is determined in accordance with difference in average values of the images in the overlapping region of the inputted images, it is possible to obtain a combined image on which appropriate and smooth tone conversion have been performed.

Other features and advantages of the present invention will be apparent from the following description taken in conjunction with the accompanying drawings, in which like reference characters designate the same or similar parts throughout the figures thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate embodiments of the invention, and together with the description, serve to explain the principles of the invention.

FIG. **1** is a view showing image pick-up conditions of inputted images according to the conventional example and the present embodiment;

FIGS. **2A** and **2B** show examples of the input image;

FIG. **3** shows an image combined in the conventional method;

FIG. **4** is a block diagram showing an arrangement of an image combining apparatus according to the first embodiment of the present invention;

FIG. **5** is a flowchart showing a process algorithm performed by a corresponding-point-extracting unit according to the first embodiment;

FIG. **6A** is a view illustrating a method of extracting a template utilized to extract corresponding points from inputted images;

FIG. 6B is a view illustrating a method of extracting a template utilized to extract corresponding points in a case where inputted images are arranged one on top of the other;

FIGS. 7A and 7B are views illustrating a method of setting a searching objective area for extracting corresponding points;

FIG. 8 is a flowchart showing a process algorithm of tone correction;

FIG. 9 is a graph showing characteristics of the relationship of sample data;

FIG. 10 shows a table which stores values of conversion functions for a tone converting unit;

FIG. 11 is a flowchart showing a process algorithm performed by an image combining unit;

FIG. 12 is an explanatory view of the image combining method;

FIG. 13 is an explanatory view of the image combining method;

FIG. 14 shows a combined image;

FIG. 15 is a graph showing variance in density in the combined image shown in FIG. 14;

FIG. 16 is an explanatory view for explaining extraction of sample data according to a modified embodiment of the first embodiment;

FIG. 17 is a graph showing characteristics of tone conversion according to a second modified embodiment of the first embodiment;

FIG. 18 is a graph showing characteristics of image combining process according to the second modified embodiment;

FIG. 19 is a block diagram showing the arrangement of the image combining apparatus and the process flow of an inputted image according to the second embodiment;

FIG. 20 is an explanatory view showing a point Pi in an image a and a corresponding point Qi in an image b, according to the second embodiment;

FIG. 21 is a flowchart showing the steps of tone correction processing performed by a correction-coefficient-determining unit and tone converting units according to the second embodiment;

FIG. 22 is an explanatory view showing sample data obtained to determine tone correction coefficients;

FIGS. 23A and 23B are graphs explaining the technique of tone correction according to the second embodiment;

FIG. 24 shows a table utilized for converting pixel values in the image b to pixel values in the image a, according to the second embodiment;

FIGS. 25A–25C are explanatory views explaining the steps of removing erroneous corresponding components by a corresponding-point-selecting unit, according to the third embodiment;

FIGS. 26A and 26B are graphs for explaining the steps of determining tone correction coefficients by a correction-coefficient-determining unit according to a third embodiment; and

FIG. 27 is an explanatory view of obtaining sample data in the fourth embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Preferred embodiments of the present invention will be described in detail in accordance with the accompanying drawings.

<First Embodiment>

FIG. 4 shows the arrangement of an image combining apparatus **1000** according to the first embodiment of the present invention.

The combine apparatus **1000** may be a single apparatus, or may be built in a camera or the like. The apparatus serves to input two input images a and b, and to output a combined image c.

Referring to FIG. 4, input images a and b are picked up by an electronic still camera or a video camera or the like in a manner such that both images partially include an overlapping region having the same image. Even if the input images a and b are picked up with different exposure conditions such as those shown in FIGS. 2A and 2B (e.g. one image picked up in a dark condition, and the other in a light condition), the combine apparatus **1000** outputs a combined image c whose boundary of the images is inconspicuous.

The combine apparatus **1000** includes a corresponding-point-extracting unit **1**, parameter estimating unit **2**, correction-coefficient-determining unit **3**, two tone converting units **4** and **5**, and image combining unit **6**.

The corresponding-point-extracting unit **1** extracts corresponding points from the two input images a and b. Herein, corresponding points are each of the respective points in two images including an identical subject, which are picked up in separate image pick-up operation by the same light source. The corresponding points are outputted in the form of vectors. The corresponding-point-extracting unit **1** identifies an overlapping region of images a and b.

A parameter estimating unit **2** estimates parameters used for image conversion for the purpose of combining the two images, on the basis of the corresponding-points vectors extracted by the extracting unit **1**.

A correction-coefficient-determining unit **3** determines coefficients used for tone correction performed on each of the input images a and b. The correction coefficients are determined on the basis of image data in the overlapping region of the input images a and b.

Tone converting units **4** and **5** respectively perform tone correction on the input images a and b such that lightness and tonality of every colors are equal in the overlapping region of the two images.

An image combining unit **6** converts the input images a and b, whose lightness has been corrected, utilizing the conversion parameters and combines the two images into a single image.

A control unit **7** controls the entire image combining apparatus.

Corresponding Point Extraction by Unit 1

Description will now be provided on the operation for generating a combined image c based on the input images a and b. Herein, description will be provided in a case where the input images a and b have N tones of density image data.

The corresponding-point-extracting unit **1** extracts corresponding points from the input images a and b to identify an overlapping region. The process algorithm performed by the corresponding-point-extracting unit **1** is shown in FIG. **5**. The algorithm shown in FIG. **5** is executed to perform template matching and extract corresponding points (i.e. overlapping region).

In step S1, the corresponding-point-extracting unit **1** determines a region which includes a template for performing template matching (hereinafter referred to as a template region). Since the frames of the input images a and b are arbitrarily set, the overlapping region cannot be determined

in advance. Thus, the extracting unit 1 sets a predetermined region as a template region.

The predetermined region can be determined in various ways.

It is assumed in the first embodiment that the image of the frame f1 is photographed first and the image of the frame f2 is photographed next. Therefore, the input image a is arranged in the left side and the input image b, in the right side. In other words, an overlapping region of the two images should be the right portion of the input image a and the left portion of the input image b. Accordingly, a predetermined region T is set as shown in FIG. 6A. The region T is located in the right portion of the image a. The horizontal length of the region T is 30% of the horizontal length of the image a, and a vertical length of the region T is 80% of the vertical length of the image a. Note that the region T is located in the center of the vertical length of the image a, with the right end thereof adjoining to the right end of the image a.

Note that in a case where the input images a and b are arranged vertically, one on top of the other, the template region T is set as shown in FIG. 6B. More specifically, the region T is located at the lower portion of the image a. The vertical length of the region T is 30% of the vertical length of the image a, and the horizontal length of the region T is 80% of the horizontal length of the image a. Note that the region T is located in the center of the horizontal length of the image a, with the lower end adjoining to the lower end of the image a.

In the process of extracting corresponding points as shown in FIG. 5, matching process is repeated for a plurality of times with respect to the region T. A region (hereinafter referred to as a searching template) subjected to single matching processing is 1/24 (=1/3×1/8) of the region T. A single searching template is indicated by "t" in FIG. 6A.

Steps S2 to S4 which will be described below are performed with respect to the region T extracted in step Si.

In step S2, the corresponding-point-extracting unit 1 determines a searching objective area S in the input image b, and within the area S, sets a searched area s which corresponds to the searching template t designated in the image a. The searching objective area S is set in the similar manner to the setting of the region T. That is, the searching objective area S as well as the searching template t are determined as shown in FIGS. 7A and 7B based on an assumption that, when a user takes photographs for generating a panoramic image, the user would set the frames f1 and f2 such that no more than 50% of the input image a overlaps the input image b in the horizontal direction, and no more than ±10% of the image a deviates in the vertical direction with the image b. More specifically, the template t which is a searched area s is set to have a size of 10 % in the vertical direction and less than 50 % (preferably, 40 %) in the horizontal direction, of the image a.

Note that if an estimated overlapping condition of the input images a and b is different, the setting of the searching objective area for extracting corresponding points may be changed.

The area S shown in FIG. 7B is the searching objective area S set in correspondence with the template t shown in FIG. 7A. The extracting unit 1 identifies a corresponding point in step S3. More specifically, the extracting unit 1 parallelly moves the template t set in the image a within the searching objective area S set in the area b, i.e. the area s is moved within the area S. The extracting unit 1 then calculates a summation of absolute values of difference between all the image data included in the searching template t and all the image data included in the area s. The extracting unit 1 determines a position in the image b having the minimum summation ΣD of the absolute values of the differences, as a corresponding point of the template t.

In step S4, the corresponding-point-extracting unit 1 determines reliability of the result of the corresponding points detected in step S3. The determination of reliability is made on the basis of the minimum value ΣD^1_{min} and the second minimum value ΣD^2_{min} of the summation ΣD of the absolute values of the differences. That is, assuming that Th_1 and Th_2 are the respective predetermined threshold values, the detected corresponding point is determined to be reliable when the following equations are satisfied:

$$\Sigma D^1_{min} \leqq Th_1 \quad (1)$$

$$\Sigma D^2_{min} - \Sigma D^1_{min} \geqq Th_2 \quad (2)$$

Then the corresponding-point-extracting unit 1 stores coordinates of the corresponding points for the images a and b respectively in a memory (not shown).

Note that in order to detect positions of the corresponding points, besides from the above technique where the position having the minimum summation ΣD of absolute values of the differences is determined as a corresponding point, the extracting unit 1 may calculate a correlation and determine a position having the largest correlation value as the corresponding point.

In addition, the corresponding position may be determined by a user. For instance, a user may designate an identical point in both images with a cursor or the like to be extracted, by referring to the two images a and b displayed on a display.

In the foregoing manner, the overlapping region of the images a and b are determined by repeatedly performing the control steps described in FIG. 5.

Determining Coordinates Conversion Parameter by Estimating Unit 2

The parameter estimating unit 2 estimates parameters for coordinates conversion on the basis of the extracted corresponding points from the overlapping region. Herein, coordinates conversion is the operation to coincide the overlapping region of the image a with the overlapping region of the image b. In the first embodiment, Affin transformation is employed.

Assuming that the image b is rotated for θ° with respect to the position of the image a, parallelly moved for a distance dx in the direction of X and a distance dy in the direction of Y, and is enlarged m times as the image a, an arbitrary point (x_a, y_a) in the image a corresponds to the point (x_b, y_b) in the image b defined by the following equation (3):

$$x_b=(\cos\theta\cdot x_a+\sin\theta\cdot y_a-dx)\times m=A\cdot x_a+B\cdot y_a+C$$

$$y_b=(-\sin\theta\cdot x_a+\cos\theta\cdot y_a-dy)\times m=-B\cdot x_a+A\cdot y_a+D$$

where

$$A=m\cdot\cos\theta$$

$$B=m\cdot\sin\theta$$

$$C=-m\cdot dx$$

$$D=-m\cdot dy \quad (3)$$

The parameter estimating unit 2 estimates the parameters A, B, C and D employing the least squares method. In order to estimate the parameters using the least squares method, at least two pairs of corresponding points are necessary.

Where only one pair of corresponding points is searched, the estimating unit 2 cannot perform matching processing since the rotation component θ cannot be determined. In such case, the estimating unit 2 assumes θ=0 and m=1, which implies that the image is not rotated. In other words, A and B are set to 1 and 0, respectively. Thus, assuming that the corresponding points vectors is denoted as (a_x, a_y), the unit 2 outputs the following parameters:

$$A=1(=\cos 0),\ B=0(=\sin 0)\ C=-a_x,\ D=-a_y \quad (4)$$

In a case where no corresponding points is obtained, the subsequent processing will not be performed; instead, for instance, a message or the like is outputted to a CRT and the processing ends. The parameters obtained in the above manner are used when an overlapping region is estimated.

Tone Conversion

In order to generate a combined image whose boundary of the images is inconspicuous, the tone converting units 4 and 5 perform tone conversion on the inputted images a and b respectively so that the lightness and tonality of colors (R, G and B) are equal in the overlapping region of the two images. The correction-coefficient-determining unit 3 determines correction coefficients for the tone conversion processing.

Meanwhile, the tone conversion on lightness components is made in the embodiment. Where the embodiment adopts color images, tone correction on each color (R, G and B) may be performed. Specifically, a tone conversion using individual tone correction function is made on each of R, G and B images.

FIG. 8 shows the process algorithm performed by the correction-coefficient-determining unit 3 and the tone converting units 4 and 5. The correction-coefficient-determining unit 3 inputs parameters A, B, C and D estimated by the estimating unit 2 for coordinates conversion, and the images a and b. The tone converting units 4 and 5 respectively input the images a and b.

In step S11 of FIG. 8, the correction-coefficient-determining unit 3 determines whether or not each pixel of the input images a and b is within the overlapping region. For determination, coordinates values of each pixel in the input images are subjected to Affin transformation according to the equation (3), utilizing the parameters A, B, C and D. Then determination is made as to whether or not the coordinates values on which Affin transformation has been performed are within the area determined to be the overlapping region of the image b.

Next, in step S12 of FIG. 8, the correction-coefficient-determining unit 3 takes samples of image data for all or a predetermined number of pixels which are determined to be included in the overlapping region. Herein, it is assumed that N number of sample pixels are obtained. In other words, pixel values $P_a(k)$ and $P_b(k)$ (k=1 to N) are obtained. The following equation (5) can be obtained if Affin transformation in equation (3) is expressed simply by matrix H:

$$S(P_b(x', y'))=P_a(x, y) \quad (5)$$

$P_a(x, y)$ represents a pixels value at (x, y) coordinate position which is not subjected to the Affin transformation. $P_b(x', y')$ represents a pixels value at (x, y) coordinate position which corresponds to the location (x', y') that has been subjected to the Affin transformation. S of the equation (5) represents a function which performs tone conversion processing in pixels which is accompanied with the above coordinate transformation. The tone conversion processing will be described in detail later.

Note that the correction-coefficient-determining unit 3 may perform the sampling of pixel values pixel by pixel, or for every arbitrary number of pixels. Moreover, the correction-coefficient-determining unit 3 may utilize, as sample data, an average value of the neighboring pixel values based on the coordinates of the corresponding points obtained by utilizing the parameters.

The correction-coefficient-determining unit 3 then obtains tone correction coefficients in step S13 of FIG. 8 on the basis of the sample data $P_a(k)$ and $P_b(k)$.

FIG. 9 shows the brief method of calculating tone correction coefficients.

Referring to FIG. 9, the abscissa indicates a density value of the sample pixel data $P_b(k)$ of the image b; and the ordinate, a density value of the sample pixel data $P_a(k)$ of the image a. In step S13 of FIG. 8, the correction-coefficient-determining unit 3 generates a conversion function (function f900 in FIG. 9) on the basis of the above sample data, to coincide the pixel density value of one image (e.g. image a) to the pixel density value of the other image (e.g. image b).

Experimentally speaking, density values of the images a and b have a distribution similar to a quadratic function. Thus, to convert a pixel value in the overlapping region of the image b to a pixel value in the overlapping region of the image a, the following quadratic function will be employed.

$$f(P_b)=T_{b1}\times P_b^2+T_{b2}\times P_b+T_{b3} \quad (6)$$

where T_{b1}, T_{b2} and T_{b3} are coefficients.

In step S13 of FIG. 8, the correction-coefficient-determining unit 3 obtains the coefficients T_{b1}, T_{b2} and T_{b3} to generate the $f(P_b)$ in equation (6). To obtain these values, the correction-coefficient-determining unit 3 calculates T_{b1}, T_{b2} and T_{b3} which minimizes an evaluation function ε expressed by the following equation:

$$\epsilon=\Sigma\{p_a(k)-(T_{b1}\times p^2_b(k)+T_{b2}\times p_b(k)+T_{b3})\} \quad (7)$$

The correction-coefficient-determining unit 3 supplies the tone converting units 4 and 5 with the calculated coefficients T_{b1}, T_{b2} and T_{b3}. Note that since the correction-coefficient-determining unit 3 calculates the coefficients to coincide the pixel values of the image b with the pixel values of the image a in the first embodiment, the tone correction coefficients T_{a1}, T_{a2} and T_{a3} for the image a are respectively, $T_{a1}=0$, $T_{a2}=1$ and $T_{a3}=0$.

Next, the tone converting units 4 and 5 convert pixel values of each of the images a and b in accordance with the tone correction coefficients T_{b1}, T_{b2} and T_{b3} in step S14 of FIG. 8. Hereinafter, the operation performed by the tone converting unit 5 will be described.

The tone converting unit 5 converts tones of the image b into tones of the image a. The tone converting unit 5 generates a table for converting the tones of the image b to the tones of the image a on the basis of the tone correction coefficients T_{b1}, T_{b2} and T_{b3}. When the dynamic range of an image is 8 bits, pixel values 0 to 255 of the image b have the values f(0) to f(255) in the space of the image a, according to the quadratic function $f(P_b)$ in equation (6). Examples of f(0) to f(255) in a conversion table 910 are shown in FIG. 10.

Although the tone converting unit 4 is capable of converting density values of the image a into density values in the space of image b, pixel values of the image a do not need to be converted in the first embodiment; thus $f(P_a)=P_a$. Therefore, the conversion table in the tone converting unit 4 converts the pixel values 0 to 255 into pixel values 0 to 255, in other words, no conversion is performed.

Note that in a case of a color image, it is preferable to perform tone conversion by generating a conversion func-

tion commonly utilized by R, G and B. Tone conversion functions for respective colors may be provided so that color matching may be improved.

Although the quadratic function is utilized as a conversion function in the first embodiment, it is possible to utilize another form of function. Needless to say, it is also possible to perform tone conversion by utilizing a non-linear table.

Combining Images

Image combining unit **6** generates a single combined image, on the basis of the input images and the images on which the tone correction has been respectively performed by the tone converting unit **4** and **5**.

The image combining unit **6** generates a combined image c in accordance with an algorithm shown in FIG. **11**.

In step **S21**, the image combining unit **6** sets an image area for the combined image c.

The area indicated by broken lines in FIG. **12** denotes the area for the combined image which has been set on the basis of a coordinates system of the input image a. Since the description of the first embodiment bases upon the coordinates of the input image a, for the purpose of a simple explanation, the upper side and the lower side of the image a are assumed to be parallel to coordinates axis X.

The image combining unit **6** first coincides the left end of the combined image c with the left end of the image a. The image combining unit **6** converts a position of the pixel **(100)** at the upper right end of the image b and a position of the pixel **(101)** at the lower right end of the image b respectively to positions in the coordinates system of the image a. Then, the image combining unit **6** coincides the right end of the combined image c with a position having a larger coordinates value between the converted two positions. In FIG. **12**, since the lower right end **101** has a larger coordinates value, the image combining unit **6** coincides the right end of the combined image c with the lower right end **101**.

Note that for the process of converting a coordinates value of image b into a coordinates value of image a to obtain a position having a larger coordinates, the image combining unit employs the inverse transformation of Affin transformation shown in FIG. **(8)**.

$$x_a = A' \cdot x_b + B' y_b + C'$$

$$y_a = -B' \cdot x_b + A' y_b + D'$$

where

$$A' = A/(A^2+B^2)$$

$$B' = -B/(A^2+B^2)$$

$$C' = (-A \cdot C + B \cdot D)/(A^2+B^2)$$

$$D' = (-B \cdot C - A \cdot D)/(A^2+B^2) \quad (8)$$

Herein, A', B', C' and D' are parameters of the inverse transformation.

Similarly (see FIG. **12**), the upper end of the combined image c is determined in the following manner. More specifically, the position of the pixel **(100)** at the upper right end of the image b and the position of the pixel **(103)** at the upper left end are converted respectively to positions in the coordinates system of the image a. The image combining unit **6** coincides the upper end of the combined image c with a position having the smallest coordinates value among the two converted positions, and the position of the pixel **(102)** at the upper left end of the image a. Furthermore, the image combining unit **6** coincides the lower end of the combined image c with a position having a larger coordinates value between the position of the pixel **(101)** at the lower right end and the position of the pixel **(105)** at the lower left end of the image b.

The combined image area c shown in FIG. **12** is determined in the above-described manner.

In step **S22** in FIG. **11**, the image combining unit **6** sets a boundary of the images so that the boundary is the center of the overlapping region. Since the images a and b are arranged side by side in the first embodiment, the boundary L which has been set in the center is indicated by broken lines L in FIG. **12**. To explain more in detail, the boundary L is set parallel to vertical coordinates axis Y. In the horizontal direction, the boundary L is set so that the two images are combined at a barycenter between the coordinates of the pixel **106** located at the lower right end of the image a and a smaller coordinates value of the two pixels **103** or **105**, respectively located at the upper left end and lower left end of the image b, which have been converted respectively to pixel positions in the coordinates system of image a.

In step **S23**, the image combining unit **6** repeatedly performs the processing in steps **S24** and **S25** on the area for the combined image c set in step **S21**.

The present invention has an object to generate a combined image whose density difference at the boundary of the images is inconspicuous. This object is partially attained by the tone correction in step **S14** in FIG. **8**. However, the tone conversion performed in step **S14** is performed independently for each of the input images a and b, therefore does not always minimize the density difference near the boundary of the images in the overlapping region. The processing performed in steps **S24** and **S25** further smoothes the density difference near the boundary of the images in the overlapping region.

As shown in FIG. **13**, a tone conversion area **150** having a predetermined width 2W is set in steps **S24** and **S25** of FIG. **11**, with the boundary L of the images as its center. In other words, the tone conversion area **150** is a rectangular area having a width W respectively to the left and right of the boundary L.

In step **S24**, the image combining unit **6** writes pixel values of the pixels of the image a in the corresponding area of the combined image area c. With respect to those pixels included in an area **140*a*** of the image a shown in FIG. **13** but not included in the tone conversion area **150**, the image combining unit **6** writes the pixel values of the original image a. With respect to a pixel P_a in the image a included in the tone conversion area **150**, the image combining unit **6** determines a tone conversion value P'_a in accordance with how far (dx_a) the pixel P_a is from the boundary L. The tone conversion value P'_a is determined by the following equation, utilizing a function f defined in the above-described conversion table (FIG. **10**) stored in the tone converting unit **4**.

$$P'_a = f(P_a) + P_a \cdot \frac{dx_a}{W} - f(P_a) \cdot \frac{dx_a}{W} \quad (9)$$

$$= P_a \cdot \frac{dx_a}{W} + f(P_a)\left(1.0 - \frac{dx_a}{W}\right)$$

According to equation (9), the tone conversion value P'_a is obtained by adding a correction term

$$P_a \cdot \frac{dx_a}{W} - f(P_a) \cdot \frac{dx_a}{W}$$

corresponding to a distance dx_a is added to the value $f(P_a)$ which has been corrected in accordance with a function f in the conversion table.

As mentioned above, since the tone converting unit coincides the tone of the image b with that of the image a in the first embodiment, f=1. Accordingly, equation (9) is expressed by the following equation:

$$P'_a = P_a \quad (10)$$

In step S25, the image combining unit 6 similarly writes pixel values with respect to the area of image b. That is, with respect to those pixels included in an area 140*b* of the image b shown in FIG. 13 but not included in the tone conversion area 150, the image combining unit 6 writes the pixel value of the original image b. With respect to a pixel P_b in the image b included in the tone conversion area 150, the image combining unit 6 determines a tone conversion value P'_b in accordance with how far (dx_b) the pixel P_b is from the boundary L. The tone conversion value P'_b is determined by the following equation, utilizing a function f' defined in the conversion table stored in the tone converting unit 5.

$$P'_b = P_b \cdot \frac{dx_b}{W} + f(P_b)\left(1.0 - \frac{dx_b}{W}\right) \quad (11)$$

FIG. 14 shows the combined image c obtained in the above-described manner.

A dummy area 160 indicated by hatching in FIG. 14 is a region where pixels of neither the image a nor image b are written. In the dummy area 160, a dummy pixel (e.g. white pixel or the like) is written.

FIG. 15 shows the variation of pixel values at an arbitrary line H in the combined image c shown in FIG. 14. In the graph in FIG. 15, the drop 170 of the pixel value P_a represents a dark subject; and the rise 171 of the pixel value P_b, a light subject.

The variance in the graph in FIG. 15 will be described next. Since the pixel values of the image a are written in the combined image area c without being processed in the first embodiment, the pixel values located in the left side of the boundary L are the pixel values of the original image a. In other words, as expressed by equation (10), the pixel values located in the left side of the boundary L are not converted even though the pixels are within the tone conversion area 150.

Meanwhile, with respect to the pixel values located in the right side of the boundary L, tone conversion performed on each pixel would be different depending upon whether the pixel is within the tone conversion area 150R (width W). More specifically, with respect to a pixel value 133 included in the tone conversion area 150R, the pixel value is converted by the equation (11) such that the value gradually changes from the pixel value 131 of the original image b to the pixel value 132 converted in accordance with the correction table (function f') stored in the tone converting unit 5.

With respect to the area outside the tone conversion area 150R, pixel values of the original image b are written.

In the foregoing description, the image combining unit 6 performs writing of pixel values for the area of image a separately from the area of the image b, dividing the combined image area by the boundary L. However, a plurality of areas may be set in the overlapping region of each image (150L and 150R), and weights may be added to the pixel values of each image in each of the plurality of areas to generate pixel values of a combined image.

The combined image c generated by the foregoing processing is outputted to a printer or the like.

<Modification of First Embodiment>

. . . First Modified Embodiment

A modification of the first embodiment (first modified embodiment) will be described next.

An image combining apparatus according to the first modified embodiment has the same arrangement as that of the first embodiment shown in FIG. 4. However the functions and operation of the correction-coefficient-determining unit 3 and the image combining unit 6 are different from those of the first embodiment. The operation will be described hereinafter.

The correction-coefficient-determining unit 3 according to the first modified embodiment determines pixel values included in the tone conversion area 150 on the basis of pixel values in the overlapping region of the input images a and b. The technique of determining thereof will be described with reference to FIG. 16.

As similar to the first embodiment, the correction-coefficient-determining unit 3 generates sample data $P_a(k)$ and $P_b(k)$ of corresponding points on the basis of the pixel values (see FIG. 16) included in the overlapping region of the image a and b. When generating the sample data, the correction-coefficient-determining unit 3 calculates an average value dP_{avg} of difference dP in each pair of corresponding points, and supplies the average value dP_{avg} to the image combining unit 6. Note that in FIG. 16, the reference letter Y denotes a lateral width of the image a. The image b has the same lateral width Y.

Assuming that the dynamic range of a pixel value is 8 bits, the image combining unit 6 sets the tone conversion area 2W on the basis of P_{avg} by the following equation:

$$2W = Y \times \frac{dP_{avg}}{255} \quad (12)$$

dP_{avg} in equation (12) denotes the difference in tones between each pair of corresponding points in the overlapping region of the images, having a maximum value 255 and a minimum value 0. According to equation (12), when the difference of the tone levels is large, the width 2W in the tone conversion area becomes large; and when the difference of the tone levels is small, the width 2W becomes small.

The foregoing description explains the technique of determining the tone conversion area according to the first modified embodiment, more specifically, the method of determining a width of the tone conversion area in correspondence with difference in tone levels, in a case where tones of the image a are different from tones of the image b in the overlapping region.

According to the first modified embodiment, a combined image is generated in the same manner as that of the first embodiment.

According to the first modified embodiment, since the tone conversion area can be suitably set in correspondence with the difference in tone levels in the overlapping region of the images, it is possible to perform smooth tone correction which is appropriate for an inputted image.

<Modification of First Embodiment>

. . . Second Modified Embodiment

The arrangement of an image combining apparatus according to the second modified embodiment is identical to

that of the first embodiment (FIG. 4). Since the method of tone correction alone is different from that of the first embodiment, the method will be described below.

The image combining apparatus according to the second modified embodiment extracts sample data on the basis of pixel values in the overlapping region of input images a and b. This operation is identical to that of the first embodiment. The correlation between a pair of pixel values P_a and P_b which are extracted as sample data is determined in accordance with the method shown in FIG. 9.

In the first embodiment, the conversion function f900 (FIG. 9) is generated to coincide tones of the image b with tones of the image a on the basis of the relationship of each sample data by utilizing the least squares method. Accordingly, in the first embodiment, conversion of pixel values performed for tone correction is executed only on the image b. In the second modified embodiment, tone correction is executed on pixel values P_a and P_b of each image.

To describe more in detail, the correction-coefficient-determining unit 3 according to the second modified embodiment generates a conversion function f as similar to the technique described in the first embodiment with reference to FIG. 9, and provides the tone converting units 4 and 5 with tone correction coefficients (T_{b1}, T_{b2} and T_{b3}) which prescribe the function f. Note that the conversion function f serves to coincide pixel values of image b with pixel values of image a, as similar to the first embodiment.

The tone converting unit 5 for converting the input image b performs tone conversion utilizing the conversion function f on the basis of the pixel values of image b. The tone conversion is executed by the following equation (13), where P_b denotes a pixel value of the original image b, and $f(P_b)$ denotes a pixel value converted by the conversion function.

$$P_b' = \frac{P_b + f(P_b)}{2} \tag{13}$$

In other words, the image combining apparatus according to the second modified embodiment performs tone conversion on the input image b, by utilizing an average value of the original pixel value P_b and the pixel value $f(P_b)$ obtained by the conversion function f.

Meanwhile, the tone converting unit 4 performs tone conversion in accordance with the following equation (14):

$$P_a' = P_a - \frac{f(P_b) - P_b}{2} \tag{14}$$

where P_a is a pixel value of the original image a.

FIG. 17 shows the brief process of tone conversion performed on the image b in accordance with equation (14). As shown in FIG. 17, $\{f(P_b)-P_b\}$ denotes an offset amount between the conversion function $f(P_b)$ and the original pixel value P_b. Equation (14) expresses that tone conversion is performed by adding/subtracting half the value of $\{f(P_b)-P_b\}$ to/from the images a and b. By virtue of this calculation, pixel values of each image gradually change, thus smooth tone correction is realized.

The pixel values converted by each of the tone converting units 4 and 5 are maintained in a form of a table as shown in FIG. 10, as similar to the first embodiment.

In the second modified embodiment, the image combining unit 6 performs writing of pixel values in the combined image c, as similar to that described in the first embodiment.

FIG. 18 shows variation of pixel values on the line H in FIG. 14 with respect to the image combined by the second modified embodiment. It is apparent from the graph that pixel values of each image are gradually changed, therefore smooth tone correction is realized.

<Second Embodiment>

FIG. 19 is a block diagram showing the arrangement of an image combining apparatus 210 and the process flow of an inputted image according to the second embodiment.

Referring to FIG. 19, the image combining apparatus 210 mainly includes: input terminals 210*a* and 210*b*; a corresponding-point-extracting unit 220 which extracts corresponding points from two input images; a corresponding-point-selecting unit 225 which removes components which are erroneously detected as corresponding points from a set of corresponding points extracted by the corresponding-point-extracting unit 220, and which selects only the correct corresponding points; a parameter estimating unit 240 which estimates parameters for combining images; a correction-coefficient-determining unit 230 which determines coefficients for tone correction of the image; tone converting units 231 and 232 which respectively correct tones of input images a and b; and an image combining unit 250 which combines two images on which tone conversion has been performed.

Images a and b are respectively input to the input terminals 210*a* and 210*b*. The input images a and b are picked up by an electronic still camera or a video camera or the like in a manner such that both images partially include an overlapping region having the same image. As similar to the first embodiment, the exposure conditions at the time of image pick-up are different for the two images.

Each of the input terminals 210*a* and 210*b* is connected to the corresponding-point-extracting unit 220, correction-coefficient-determining unit 230, and tone converting units 231 and 232. The input images a and b are sent to the corresponding-point-extracting unit 220 where corresponding points are extracted from each of the images a and b.

The corresponding-point-extracting unit 220 is connected to the corresponding-point-selecting unit 225 and the parameter estimating unit 240. The corresponding points extracted by the corresponding-point-extracting unit 220 are sent to the corresponding-point-selecting unit 225 and the parameter estimating unit 240. The corresponding-point-selecting unit 225 and the parameter estimating unit 240 are interactively connected to each other. On the basis of coordinates conversion parameters estimated by the parameter estimating unit 240 and a coordinates value indicative of the corresponding points extracted by the corresponding-point-extracting unit 220, the corresponding-point-selecting unit 225 removes components which are erroneously detected as corresponding points from the corresponding points extracted by the corresponding-point-extracting unit 220, and sends the result to the parameter estimating unit 240. The parameter estimating unit 240 estimates parameters for image conversion on the basis of the result where erroneous corresponding points have been removed.

The parameter estimating unit 240 is connected to the correction-coefficient-determining unit 230 and image combining unit 250. The image conversion parameters estimated by the parameter estimating unit 240 is sent to the correction-coefficient-determining unit 230 and the image combining unit 250.

The correction-coefficient-determining unit 230, which holds images a and b inputted by the input terminals 210*a* and 210*b* and image conversion parameters (A, B, C and D) estimated by the parameter estimating unit 240, determines coefficients (T_a and T_b) for tone correction of an image on the basis of the image included in the overlapping region of

the images a and b. The correction-coefficient-determining unit **230** is connected to the tone converting units **231** and **232**. The correction-coefficient-determining unit **230** sends the determined coefficients (T_a and T_b) to the tone converting units **231** and **232**, respectively. The tone converting units **231** and **232** perform tone conversion on each of the images a and b utilizing the coefficient (T_b) sent by the correction-coefficient-determining unit **230**, so that lightness is equal in the overlapping region of the images a and b.

Each of the tone converting units **231** and **232** is connected to the image combining unit **250**. The image combining unit **250** converts the images a and b, on which tone correction bas been performed respectively by the tone converting units **231** and **232**, by utilizing the parameters estimated by the parameter estimating unit **240** and combines the two images into a single image.

In the foregoing arrangement, the control unit **270** controls the entire image combining apparatus.

As will be described later, the second embodiment largely differs from tbe first embodiment by including the corresponding-point-selecting unit **225**.

Hereinafter, the operation of the image combining apparatus **210** will be described in a case where a combined image c is generated based on the images a and b. Note that in the second embodiment, the input images a and b each includes density image data baving N number of tones.

Extracting Corresponding Points

The input two images a and b are first sent to the corresponding-point-extracting unit **220** where corresponding points are extracted.

The processing for extracting corresponding points performed by the corresponding-point-extracting unit **220** is substantially identical to the processing performed by the extracting unit **1** in the first embodiment. In other words, the extracting unit **220** in the second embodiment executes substantially tbe same processing steps as the extraction processing steps (FIG. **5**) in the first embodiment. That is, the extracting unit **220** extracts a set of corresponding points by performing template matcbing.

Estimating Coordinates Conversion Parameters

The corresponding-point-extracting unit **220** sends the extracted corresponding points to the parameter estimating unit **240** and the corresponding-point-selecting unit **225**.

The parameter estimating unit **240** estimates parameters (A, B, C and D) for coordinates conversion, on the basis of the extracted corresponding points.

The second embodiment also requires coordinates conversion to coincide the overlapping region of the image a with the overlapping region of the image b. Thus, Affin transformation is employed as similar to the first embodiment. Accordingly, the parameter estimating unit **240** according to the second embodiment determines parameters A, B, C and D to be applied to the Affin transformation expressed by equation (3), and outputs the result to the correction-coefficient-determining unit **230**. In other words, the estimating unit **240** according to the second embodiment is substantially identical to the estimating unit **3** according to the first embodiment.

Selecting Corresponding Points

A set of corresponding points extracted by the corresponding-point-extracting unit **220** and coordinates conversion parameters (A, B, C and D) estimated by the parameter estimating unit **240** are input to the corresponding-point-selecting unit **225**. The corresponding-point-selecting unit **225** removes erroneously detected corresponding points from tbe set of corresponding points extracted by the corresponding-point-extracting unit **220**. By virtue of this process, corresponding points, wbich will be utilized by the parameter estimating unit **240** for estimating image conversion parameters, are narrowed down to more appropriate values. The template matching, performed by the extracting unit **220** to extract corresponding points, bas a possibility of erroneous recognition. Therefore, the corresponding points must be reconfirmed by a method different from template matching.

FIG. **20** illustrates processing performed by the selecting unit **225** where determination is made as to whether or not the corresponding points are erroneously recognized. In FIG. **20**, it is assumed that a set of plural pairs of points $P_i(x, y)$ and $Q_i(x', y')$ (i=0, 1, . . .) is a set of corresponding points of images a and b. The corresponding-point-selecting unit **225** utilizes the Affin transformation parameters A, B, C and D obtained by the parameter estimating unit **240** to detect components of erroneous corresponding points in accordance with the following equation:

$$|x'-(A\cdot x+B\cdot y+C)|<Th$$
$$|y'-(-B\cdot x+A\cdot y+D)|<Th \qquad (15)$$

In equation (15), (A·x+B·y+C) and (−B·x+A·y+D) respectively indicate coordinates (x, y) of an arbitrary point (estimated to be one of corresponding points) on the image a on which Affin transformation has been performed. Accordingly, if an absolute value of the difference between the coordinates (A·x+B·y+C, −B·x+A·y+D), on which Affin transformation has been performed on (x, y), and coordinates (x', y') on the image b, is larger than a threshold value Th, (i.e. if equation (15) is not satisfied), the pair of corresponding points $P_i(x, y)$ and $Q_i(x', y')$ is considered to be erroneously recognized.

The corresponding-point-selecting unit **225** selects only the corresponding points that satisfy equation (15) from the set of corresponding points obtained by the corresponding-point-extracting unit **220**.

Referring to FIG. **20**, arrows indicated by solid lines and broken lines represent movement of positions of the points according to Affin transformation. For instance, a pair of corresponding points indicated by the solid line, e.g. a pair of points P_0 and Q_0 or a pair of points P_2 and Q_2 is selected as the pair of corresponding points because the position obtained after Affin transformation and a position assumed to be the corresponding point are substantially equal. On tbe other hand, a pair of corresponding points P_1 and Q_1 or a pair of points P_3 and Q_3 obtained by the corresponding-point-extracting unit **220** is deviated for more than a threshold value, from the coordinates obtained on the basis of aforementioned parameters. These corresponding points are removed as erroneously recognized components.

Referring back to FIG. **19**, the corresponding-point-selecting unit **225** sends tbe result of selection to the parameter estimating unit **240**. The parameter estimating unit **240** estimates parameters used for combining images by utilizing the selected corresponding points. As set forth above, parameters for combining images are estimated on the basis of coordinates of corresponding points from which erroneous components have been removed. Therefore, the image combining apparatus can generate a more precise combined image.

Tone Correction Processing

The parameter estimating unit **240** sends the estimated parameters (A, B, C and D) to the correction-coefficient-determining unit **230**. The correction-coefficient-determining unit **230** determines correction coefficients to be utilized by the tone converting units **231** and **232** for tone correction.

FIG. 21 is a flowchart showing the tone correction processing performed by the correction-coefficient-determining unit **230** and tone converting units **231** and **232**.

Sample pixels are first obtained from images a and b to determine tone correction coefficients (step S31).

FIG. **22** illustrates obtained sample pixels. The correction-coefficient-determining unit **230** first determines on the basis of the image combine parameters (A, B, C and D) estimated by the parameter estimating unit **240**, as to whether or not a coordinates value of a sample pixel P_{a1} of the image a is within the overlapping region. To make determination, the correction-coefficient-determining unit **230** converts the coordinates value of a sample pixel P_{a1} of the image a into a coordinates value of image b by Affin transformation utilizing equation (3), and makes determination as to whether or not the converted coordinates value is included in the image b. If it is determined that the sample pixel P_{a1} is in the overlapping region of the images a and b, a coordinates value corresponding to the sample pixel P_{a1} in the image b is set to be a sample pixel P_{b1}. The correction-coefficient-determining unit **230** performs the same process on a plurality of sample pixels P_{a1} to P_{ak} (k =1 to N) of the input image a, and the obtained pixel values will be set as sample pixels P_{b1} to P_{bk} (k=1 to N).

Note that, as similar to the first embodiment, the correction-coefficient-determining unit **230** may perform the sampling of pixel values pixel by pixel, or for every arbitrary number of pixels. Moreover, the correction-coefficient-determining unit **230** may utilize, as sample data, an average value of neighboring pixel values based on the coordinates of the corresponding points obtained by utilizing the image combine parameters.

Referring back to FIG. **21**, the correction-coefficient-determining unit **230** obtains tone correction coefficients of the image a on the basis of sample pixels P_{ak} and P_{bk} obtained in the foregoing manner (step S32). The tone correction coefficients are calculated as a coefficient of a tone correction function f_a.

The method of performing tone correction according to the second embodiment will be described with reference to FIG. **23**A. In FIG. **23**A, the abscissa indicates tones of an image before correction, and the ordinate indicates tones after correction.

First, average values $Avg(P_a)$ and $Avg(P_b)$ of the sample pixels P_{ak} and P_{bk} of the images a and b are calculated, and difference D of each average value is calculated by the following equation:

$$D = Avg(P_a) - Avg(P_b) \tag{16}$$

Then, as shown in FIG. **23**A, a correction function f_a is determined so that the tones of the image a can be expressed by a quadratic function (tone correction function) passing through three points: (0, 0), (255, 255) and (128, 128+D/2). Herein, since an arbitrary quadratic function can be defined by three parameters, it is assumed that the tone correction function f_a is defined to be T_{a1}, T_{a2} and T_{a3}. In addition, a value obtained by converting the sample pixel P_{ak} of the image a utilizing the tone correction function f_a, is defined to be $f_a(P_{ak})$.

Referring back to the flowchart in FIG. **21**, upon calculating the coefficients (T_{a1}, T_{a2} and T_{a3}) of the tone correction function f_a of the image a, the correction-coefficient-determining unit **230** calculates coefficients (T_{b1} T_{b2} and T_{b3}) of the tone correction function f_b of the image b (step S33).

The tone correction function f_b is obtained to be utilized as a function to coincide the sample pixel P_{bk} with sample pixel $f_a(P_{ak})$. The coefficients (T_{b1}, T_{b2} and T_{b3}) of the tone correction function f_b are calculated by the least squares method, utilizing the sample pixels shown in FIG. **23**B, to minimize ϵ in equation (17).

$$\epsilon = \{f_a(P_{ak}) - (T_{b1} \times p_{bk}^2 + T_{b2} \times p_{bk} + T_{b3})\}^2 \tag{17}$$

In accordance with the foregoing processing, tone correction functions f_a and f_b for converting tones of the images a and b are obtained by the following equation (18):

$$f_a(i) = T_{a1} \cdot i^2 + T_{a2} \cdot i + T_{a3}$$

$$f_b(i) = T_{b1} \cdot i^2 + T_{b2} \cdot i + T_{b3} \tag{18}$$

where i denotes tones before conversion. The correction-coefficient-determining unit **230** sends the calculated tone correction coefficients T_a and T_b respectively to the tone converting units **231** and **232**.

Referring back to the flowcharts in FIG. **21**, the tone converting units **231** and **232** respectively convert each of the pixel values of images a and b utilizing each of the tone correction coefficients sent by the correction-coefficient-determining unit **230** (step S34).

The operation of the tone converting unit **232** is described below. Note that the tone converting unit **231** executes the same operation as that of the tone converting unit **232**.

In the tone converting unit **232**, a table is generated to convert tones of the image b on the basis of tone correction coefficients T_{b1}, T_{b2} and T_{b3}. More specifically, assuming that the dynamic range of the image is 8 bits, a table as shown in FIG. **24** is generated to convert a pixel value (0 to 255) of the image b into a pixel value $f_b(0)$–$f_b(255)$ according to the quadratic function in equation (18).

Note that in a case of a color image, the tone converting unit may perform tone conversion for each of the colors R, G and B. Alternatively, the tone converting unit may perform tone conversion by generating a conversion function commonly used for the colors R, G and B in accordance with a luminance signal. In this regard, the function f_a which corrects tonality of the image a may be generated on the basis of pixel values of G image signals. All the R, G and B components of the image a may be converted by the function f_a. Conversion functions f_b for R, G, B colors of the image b are generated in such a manner that pixel values of each color component of the converted image b by f_b may match with those of the image a converted by using the function f_a.

Furthermore, although the quadratic function is utilized in the above description, another form of function may be utilized. It is also apparent that tone conversion may be performed by utilizing a non-linear table.

Combining Images

The tone converting units **231** and **232** sends the images a and b, on which tone conversion has been performed, to the image combining unit **250** where the images are combined into a single image. Since the process of combining images is identical to that of the first embodiment (FIG. **11**), detailed description thereof will be omitted.

As has been described above, according to the image combining apparatus of the second embodiment, erroneously detected corresponding points are first determined in an overlapping region of images a and b partially having the same subject. Then, on the basis of a result of extracted corresponding points from which the erroneously detected corresponding points are removed, parameters (A, B, C and D) for combining the images are determined. Next, sample pixels (P_{ak} and P_{bk}) used for tone correction are generated, utilizing the image combine parameters, and a tone correction coefficient (T_a) of the image a is calculated on the basis

of an average value of the sample pixels. On the basis of the sample pixels of the image a on which tone correction has been performed utilizing the tone correction coefficient, a tone correction coefficient (T_b) of the image b is calculated. Since the images a and b are combined after tone correction is performed on the images a and b utilizing each of the tone correction coefficients calculated in the foregoing manner, it is possible to generate a combined image whose boundary of the images is inconspicuous, even in a case where the two images have different exposure conditions.

Furthermore, on account of the tone conversion of the image a performed on the basis of an average level of the pixel values in the overlapping region of the images, which is obtained in accordance with the above described image parameters, and also on account of the correction performed to coincide the tones of the image b with the corrected tones of the image a, the corrected tones of the images a and b are natural.

<Modification of Second Embodiment>

. . . Third Modified Embodiment

Next, a modification of the second embodiment (third modified embodiment) will be described with reference to FIGS. 25A to 26B.

An image combining apparatus according to the third modified embodiment has the same arrangement as that of the second embodiment shown in FIG. 19. However, functions and operation of the corresponding-point-extracting unit **220**, corresponding-point-selecting unit **225** and correction-coefficient-determining unit **230** are different from those of the second embodiment. Hereinafter, description thereof will be provided.

Unlike the corresponding-point-extracting unit of the second embodiment, the corresponding-point-extracting unit **220** of the image combining apparatus **210** according to the third modified embodiment does not determine (step S4 in FIG. 5) reliability of corresponding points obtained by matching operation. Instead, the third modified embodiment recognizes a position having a minimum value of non-coincidence as a corresponding point.

The corresponding-point-selecting unit **225** repeats the process of removing erroneous corresponding points which is shown in the aforementioned equation (15), thereby enhancing accuracy in extracting corresponding points.

FIGS. 25A–25C are explanatory views for explaining the steps of removing erroneous corresponding points performed by the corresponding-point-selecting unit **225**.

In accordance with a result of extraction (FIG. 25A) obtained by the corresponding-point-extracting unit **220**, the parameter estimating unit calculates image conversion parameters A, B, C and D. The difference of each pair of corresponding points is then obtained in accordance with equation (15). Next, average values Avg(dx) and Avg(dy) of the differences are calculated. In the third modified embodiment, the average value of the differences is used as a threshold value. More specifically, the corresponding-point-selecting unit **225** removes erroneously recognized corresponding points as shown in FIG. 25B utilizing the values Th_x=Avg(dx) and Th_y=Avg(dy).

The corresponding-point-selecting unit **225** repeats the above processing until the average values Avg(dx) and Avg(dy) of the differences are converged to a predetermined value. The resultant corresponding points (FIG. 25C) are sent to the parameter estimating unit **240** where image combine parameters are estimated.

As similar to the second embodiment, the correction-coefficient-determining unit **230** obtains tone correction coefficients T_a and T_b on the basis of the sample pixels P_{ak} and P_{bk} obtained in the steps S32 and S33 in the flowchart in FIG. 21.

FIGS. 26A and 26B are graphs for explaining the steps of determining tone correction coefficients by the correction-coefficient-determining unit **230**.

More specifically, the correction-coefficient-determining unit **230** calculates the average values Avg(P_a) and Avg(P_b) of the sample pixels P_{ak} and P_{bk} obtained from each of the images a and b, and further calculates difference D of each of the average values. As shown in FIG. 26A, tones of the image a are converted such that the tones are expressed by the linear function f_a' passing through the points (0, 0) and (128, 128+D/2). The sample pixel P_{ak} of the image a is converted in accordance with the tone correction function f_a', and the converted sample pixel is defined to be $f_a'(P_{ak})$. Note that the coefficients of the tone correction function f_a' are T_{a1}' and T_{a2}'.

Furthermore, tone correction coefficient f_b' is generated to coincide the sample pixel P_{bk} with the sample pixel $f_a'(P_{ak})$ The abscissa in FIG. 26B indicates tones before correction, and the ordinate indicates tones corrected by utilizing the tone correction coefficient f_b'.

The coefficients T_{b1}, T_{b2} and T_{b3} utilized to generate the tone correction function f_b' are calculated by the least squares method utilizing the sample pixels shown in FIG. 26B, to minimize ϵ in equation (17).

In accordance with the foregoing processing, tone correction function f_a' and f_b' for converting tones of the images a and b are obtained by the following equation (19):

$$f_a'(i)=T_{a1}\cdot i+T_{a2}$$
$$f_b'(i)=T_{b1}\cdot i^2+T_{b2}\cdot i+T_{b3} \qquad (19)$$

where i denotes tones before conversion.

As set forth above, according to the third modified embodiment, the corresponding-point-extracting unit does not determine the reliability of the corresponding points obtained by matching processing. Instead, a position having a minimum value of non-coincidence is recognized as a corresponding point. By virtue of this processing, it is possible to improve accuracy in extracting corresponding points. In addition, image combine parameters are set in accordance with the corresponding points having high precision from which erroneous corresponding points are removed. Further, the sample pixels for tone correction are generated by utilizing the image combine parameters. Therefore, it is possible to generate a combined image whose boundary of the images is inconspicuous, even in a case where the two images have different exposure conditions.

<Modification of Second Embodiment>

. . . Fourth Modified Embodiment

The fourth modified embodiment will be described next with reference to FIG. 27.

The arrangement of the image combining apparatus according to the fourth modified embodiment is identical to that of the second embodiment shown in FIG. 19. However, the operation of the correction-coefficient-determining unit **230** is different from that of the second embodiment. Hereinafter the operation thereof will be described.

In the foregoing second embodiment and the third modified embodiment, the correction-coefficient-determining unit obtains the sample pixels P_{ak} and P_{bk} shown in FIG. 22 which are utilized to generate tone correction coefficients, from pixel values of corresponding points between the images a and b, which are obtained on the basis of Affin transformation parameters (A, B, C and D). In the fourth modified embodiment, matching processing is performed in the neighbor of coordinates of the corresponding points

which are obtained on the basis of Affin transformation parameters, so that sample pixels are obtained with high precision.

The operation of obtaining sample pixels according to the fourth modified embodiment will be described with reference to FIG. 27.

In FIG. 27, points P and P' are a pair of corresponding points obtained on the basis of Affin transformation parameters. Herein, the template T is generated with the point P as the center of the image a'. Matching operation is executed with respect to points in the template T, within the range of the searching objective area S of the image b' having a point P' as its center. The obtained corresponding point is defined as a point P" which precisely coincides with the point P. Accordingly, deviation of sample pixels conventionally generated due to errors in the parameters is corrected (an error generated between P'–P"), thus more accurate sample pixels are generated.

The result of the matching processing is determined to be correct if a value of non-coincidence at a peak value is lower than a threshold value.

Suppose that a matched position cannot be found in the searching objective area S, sample pixels may be generated by utilizing coordinates of a corresponding point which is obtained by Affin transformation.

The tone correction process of the images a' and b', generation process of a combined image c' performed by the image combining unit **250** are performed similar to that of the second embodiment.

As set forth above, according to the fourth modified embodiment, highly accurate sample pixels can be obtained by performing matching processing in the neighbor of the coordinates of the corresponding points obtained on the basis of Affin transformation parameters.

The present invention is not limited to the above embodiments and various changes and modifications can be made within the spirit and scope of the present invention. Therefore, to appraise the public of the scope of the present invention, the following claims are made.

What is claimed is:

1. An image combining apparatus for combining a first image and a second image having an overlapping region which overlaps with the first image, comprising:

identifying means for discriminating the overlapping region within the first and second images, and identifying a first partial image corresponding to the overlapping region of the first image and a second partial image corresponding to the overlapping region of the second image;

detecting means for detecting corresponding pixels between the first partial image and the second partial image, and detecting tone densities of the first and second partial images on the basis of detected corresponding pixels;

tone correction means for performing tone correction on at least one of the corresponding pixels of the first partial image and those of the second partial image on the basis of a difference in tone density of the first partial image and the second partial image so that the tone density of the at least one partial image approximates to the other; and

combining means for combining the first image and the second image, substituting image data in the overlapping region with image data indicative of the corrected first partial image and the second partial image.

2. The image combining apparatus according to claim **1**, wherein said detecting means comprises calculating means for calculating a correction function which prescribes a correlation between the tone density of the first partial image and the tone density of the second partial image, and said tone correction means performs tone correction on either the first image or the second image utilizing the calculated correction function.

3. The image combining apparatus according to claim **2**, wherein the correlation is approximated by a quadratic function.

4. The image combining apparatus according to claim **1**, wherein said combining means adds weights to at least one of the first and second images corrected by said tone correction means, adds the weighted image to the original image, and combines the added image with the other image.

5. The image combining apparatus according to claim **1**, further comprising:

setting means for setting a boundary at a substantial center of the overlapping region, wherein said combining means performs correction on pixels of the second partial image in correspondence with a distance from the boundary to the pixel.

6. The image combining apparatus according to claim **1**, wherein said combining means sets a tone conversion area in the overlapping region.

7. The image combining apparatus according to claim **5**, wherein said combining means performs tone conversion only on the second partial image.

8. The image combining apparatus according to claim **5**, wherein said combining means performs tone conversion on the first partial image and the second partial image.

9. The image combining apparatus according to claim **5**, wherein said combining means changes a size of the tone conversion area in accordance with a difference in density of the first partial image and density of the second partial image.

10. The image combining apparatus according to claim **5**, wherein said combining means sets the tone conversion area in accordance with a difference in each average value of the first image and the second image within the overlapping region.

11. The image combining apparatus according to claim **1**, wherein said identifying means determines mapping of coordinates conversion from a space of the first partial image to a space of the second partial image, and

said combining means utilizes inverse transformation of said mapping to map the second partial image into the space of the first partial image, thereby combining the first image and the second image.

12. An image combine method of combining a first image and a second image having an overlapping region which overlaps with the first image, comprising the steps of:

discriminating the overlapping region within the first and second images to identify a first partial image corresponding to the overlapping region of the first image and a second partial image corresponding to the overlapping region of the second image;

detecting means for detecting corresponding pixels between the first partial image and the second partial image, and detecting tone densities of the first and second partial images on the basis of detected corresponding pixels;

performing tone correction on at least one of the corresponding pixels of the first partial image and those of the second partial image on the basis of a difference in tone density of the first partial image and the second partial image so that the tone density of the at least one partial image approximates to the other; and

combining the first image and the second image, with substitution of image data in the overlapping region with image data indicative of the corrected first partial image and the second partial image.

13. The apparatus according to claim 1, wherein said identifying means comprises:

corresponding-point-extracting means for extracting a set of corresponding points from the first image and the second image; and

removing means for removing from the set of corresponding points, data indicative of corresponding points which are erroneously detected as corresponding points by said corresponding-point-extracting means, on the basis of coordinates conversion parameters estimated by utilizing the set of corresponding points extracted by said corresponding-point-extracting means,

wherein said combining means estimates image combine parameters on the basis of the set of corresponding points from which erroneous corresponding points have been removed.

14. The image combining apparatus according to claim 13, wherein said tone correction means extracts pixel values of the set of corresponding points, from which the erroneous corresponding points have been removed, respectively from the first image and the second image on the basis of the estimated image combine parameters, and performs tone correction respectively on the first and second images utilizing the extracted pixel values.

15. The image combining apparatus according to claim 13,

wherein said tone correction means generates a first correction function for performing tone correction on the first image on the basis of a difference between an average value of the pixel values extracted from the first image and an average value of the pixel values extracted from the second image,

performs tone correction on the first image utilizing the fist correction function,

generates a second correction function to coincide the pixel values of the corresponding points in the second image from which the erroneous corresponding points have been removed by said removing means, with the pixel values of the corresponding points in the corrected first image from which the erroneous corresponding points have been removed, and

performs tone correction on the second image utilizing the second correction function.

16. The image combine method according to claim 12, wherein said identifying step comprises the steps of:

extracting a set of corresponding points from the first image and the second image; and

removing, from the set of corresponding points, data indicative of corresponding points which are erroneously detected as corresponding points in said extracting step, on the basis of coordinates conversion parameters estimated by utilizing the set of corresponding points extracted in said extracting step,

wherein in said combining step, image combine parameters are estimated on the basis of the set of corresponding points from which erroneous corresponding points have been removed.

17. The image combine method according to claim 16, wherein said step of performing tone correction comprises the steps of:

extracting pixel values of the set of corresponding points, from which the erroneous corresponding points have been removed, respectively from the first image and the second image on the basis of the estimated image combine parameters; and

performing tone correction respectively on the first and second images utilizing the extracted pixel values.

18. The image combine method according to claim 16, wherein said step of performing tone correction comprises the steps of:

generating a first correction function for performing tone correction on the first image on the basis of a difference between an average value of the pixel values extracted from the first image and an average value of the pixel values extracted from the second image;

performing tone correction on the first image utilizing the fist correction function,

generating a second correction function to coincide the pixel values of the corresponding points in the second image from which the erroneous corresponding points have been removed in said removing step, with the pixel values of the corresponding points in the corrected first image from which the erroneous corresponding points have been removed, and

performing tone correction on the second image utilizing the second correction function.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 5,982,951
DATED : November 9, 1999
INVENTOR(S) : Katayama et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 5:
Line 38, delete "Si" and insert therefore -- S1 --.

Column 17:
Line 63, delete "T_{b1} T_{b2}"and insert therefor -- T_{b1},T_{b2} --.

Signed and Sealed this

Nineteenth Day of June, 2001

Attest:

Nicholas P. Godici

Attesting Officer

NICHOLAS P. GODICI
Acting Director of the United States Patent and Trademark Office

US006593938B1

(12) **United States Patent**
Sakata et al.

(10) **Patent No.: US 6,593,938 B1**
(45) **Date of Patent: *Jul. 15, 2003**

(54) **IMAGE PROCESSING APPARATUS, METHOD AND COMPUTER-READABLE RECORDING MEDIUM WITH PROGRAM RECORDED THEREON, FOR JOINING IMAGES TOGETHER BY USING VISIBLE JOINING POINTS AND CORRECTING IMAGE DISTORTION EASILY**

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(73) Assignee: **Ricoh Company, Ltd.**, Tokyo (JP)

(*) Notice: This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(a)(2).

Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/290,553**

(22) Filed: **Apr. 12, 1999**

(30) **Foreign Application Priority Data**

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Jul. 10, 1998 (JP) 10-196278
Jul. 10, 1998 (JP) 10-196280

(51) **Int. Cl.**[7] **G09G 5/00**; G06K 9/36; H04N 9/74

(52) **U.S. Cl.** **345/629**; 382/284; 348/584

(58) **Field of Search** 345/435, 629; 348/584; 382/284

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,469,536 A * 11/1995 Blank 345/431
5,982,951 A * 11/1999 Katayama et al. 382/284
5,986,670 A * 11/1999 Dries et al. 345/435
6,064,399 A * 5/2000 Teo 345/435
6,078,701 A * 6/2000 Hsu et al. 345/435
6,128,108 A * 10/2000 Teo 358/1.9
6,157,747 A * 12/2000 Szeliski et al. 345/435
6,167,167 A * 12/2000 Matsugu et al. 345/435

FOREIGN PATENT DOCUMENTS

JP 9294225 11/1997

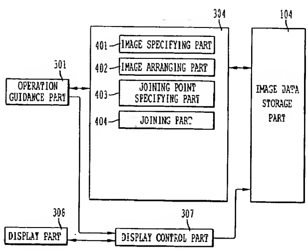
* cited by examiner

Primary Examiner—Jeffery Brier
Assistant Examiner—Anthony Blackman
(74) *Attorney, Agent, or Firm*—Oblon, Spivak, McClelland, Maier & Neustadt, P.C.

(57) **ABSTRACT**

An image processing apparatus is provided with a display device to display images on a display screen so that the images displayed on the display device can be edited and processed for joining of the images. The image processing apparatus includes an image specifying device to specify two or more images to be joined together on the display device. An image arranging device arranges the images specified by the image specifying device in such an order as to join the images together, and a display control device controls the display device to display the images arranged by the image arranging device. A joining point specifying device specifies any one joining point for each image so that vertically or laterally adjacent images displayed by the display control device can be joined together by referring to the joining points. A joining device joins adjacent images together by referring to the joining points specified by the joining point specifying device. This makes it possible to easily join the images together by such a way as to merely specify one joining point for each image, and hence to execute image joining easily and efficiently.

63 Claims, 48 Drawing Sheets



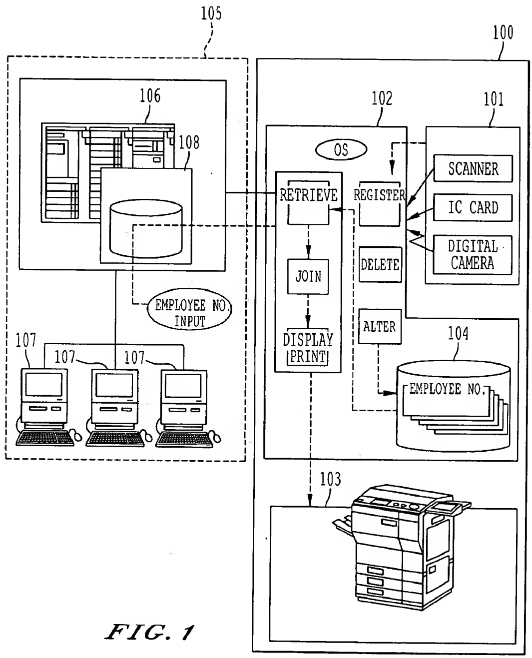

105
100
106
108
102
101
OS
SCANNER
RETRIEVE
REGISTER
IC CARD
DIGITAL CAMERA
DELETE
JOIN
EMPLOYEE NO. INPUT
ALTER
104
107
107
107
DISPLAY PRINT
EMPLOYEE NO.
103

FIG. 1

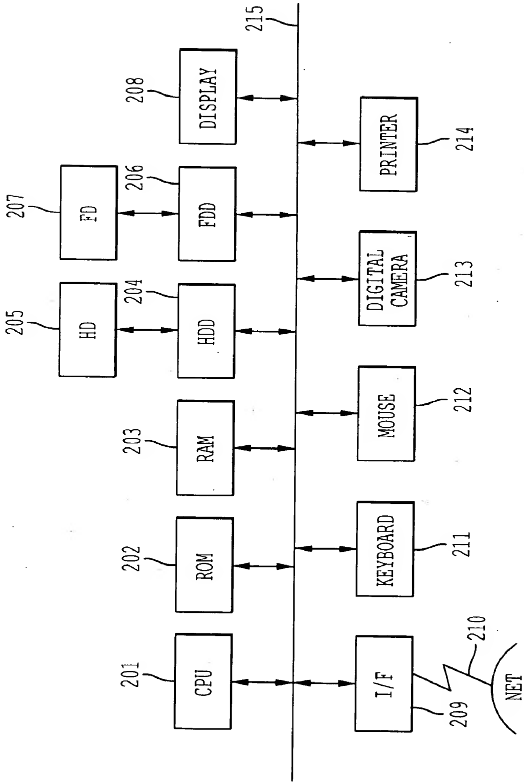

215
DISPLAY
208
FD
207
FDD
206
HD
205
HDD
204
RAM
203
ROM
202
CPU
201
PRINTER
214
DIGITAL CAMERA
213
MOUSE
212
KEYBOARD
211
I/F
209
210
NET

FIG. 2

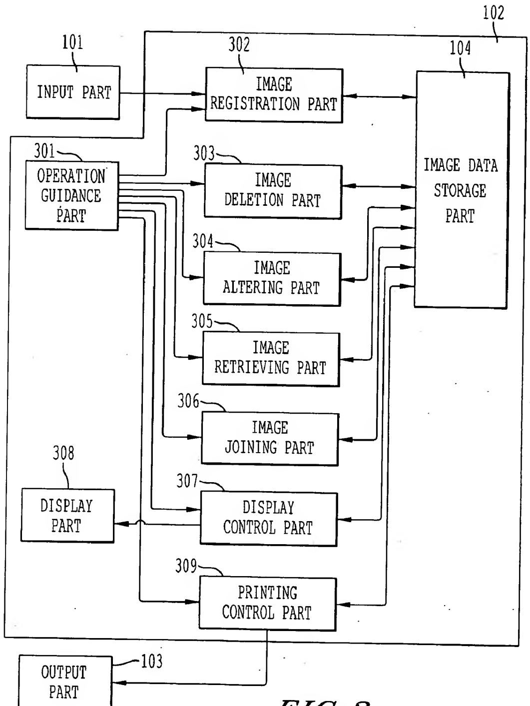

102
101
INPUT PART
302
IMAGE REGISTRATION PART
104
IMAGE DATA STORAGE PART
301
OPERATION GUIDANCE PART
303
IMAGE DELETION PART
304
IMAGE ALTERING PART
305
IMAGE RETRIEVING PART
306
IMAGE JOINING PART
308
DISPLAY PART
307
DISPLAY CONTROL PART
309
PRINTING CONTROL PART
OUTPUT PART
103

FIG. 3

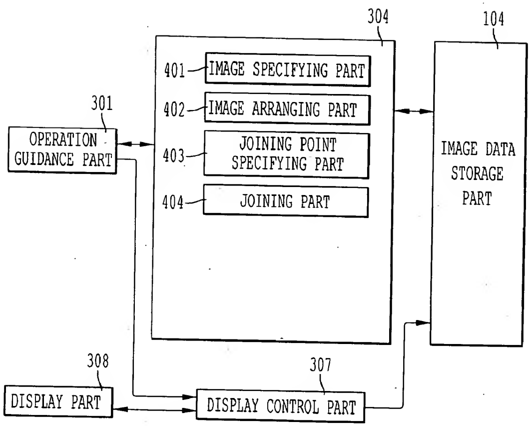

304
104
401
IMAGE SPECIFYING PART
402
IMAGE ARRANGING PART
301
OPERATION GUIDANCE PART
403
JOINING POINT SPECIFYING PART
IMAGE DATA STORAGE PART
404
JOINING PART
308
307
DISPLAY PART
DISPLAY CONTROL PART

FIG. 4

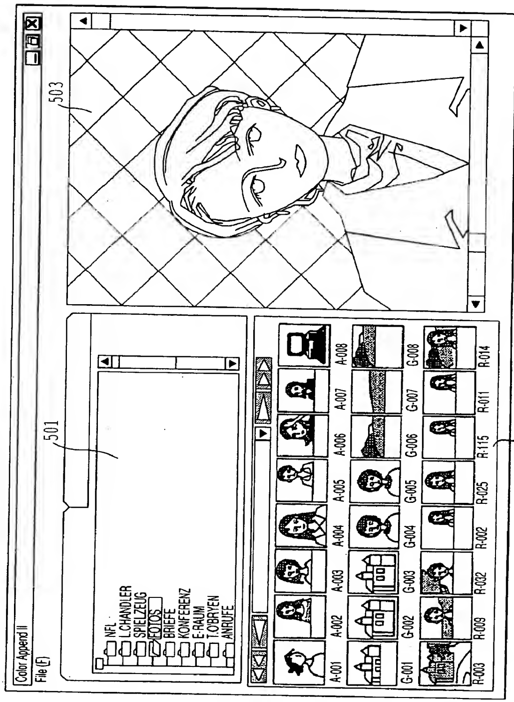

Color Append II
File (F)
NFL
L.CHANDLER
SPIELZEUG
FOTOS
BRIEFE
KONFERENZ
E-RAUM
T.OBRYEN
ANRUFE
501
502
503
A-001
A-002
A-003
A-004
A-005
A-006
A-007
A-008
G-001
G-002
G-003
G-004
G-005
G-006
G-007
G-008
R-003
R-009
R-032
R-002
R-025
R-115
R-011
R-014

FIG. 5

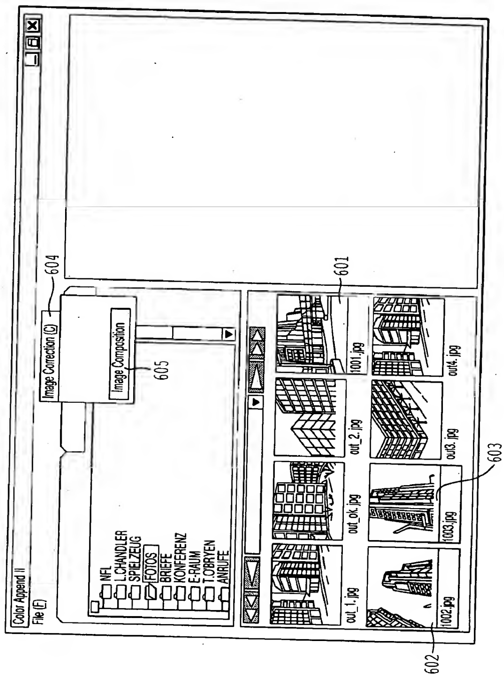

Color Append II
File (F)
Image Correction (C)
604
Image Composition
605
NFL
L.CHANDLER
SPIELZEUG
FOTOS
BRIEFE
KONFERENZ
E-RAUM
T.O'BRYEN
ANRUFE
601
1001.jpg
out_2.jpg
out_ok.jpg
out_1.jpg
out4.jpg
out3.jpg
1003.jpg
1002.jpg
603
602

FIG. 6

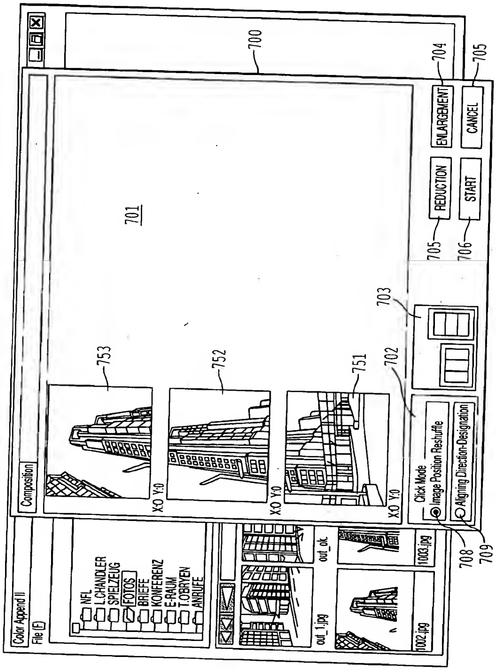

Color Append II
File (F)
NFL
L.CHANDLER
SPIELZEUG
FOTOS
BRIEFE
KONFERENZ
E-RAUM
T.O'BRYEN
ANRUFE
out_1.jpg
out_ok.
1002.jpg
1003.jpg
Composition
700
701
753
752
751
702
703
X:0 Y:0
X:0 Y:0
X:0 Y:0
Click Mode
Image Position Reshuffle
Aligning Direction-Designation
708
709
REDUCTION
ENLARGEMENT
START
CANCEL
705
704
706
705

FIG. 7

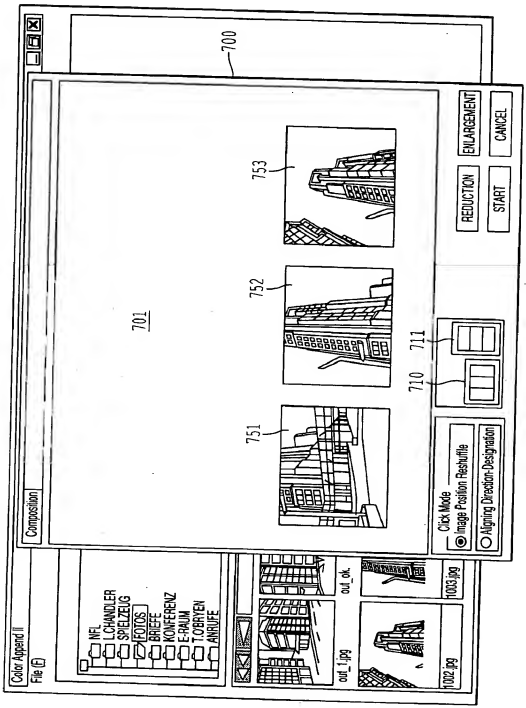

Color Append II
File (F)
700
Composition
701
751
752
753
NFL
L.CHANDLER
SPIELZEUG
FOTOS
BRIEFE
KONFERENZ
E-RAUM
T.O'BRYEN
ANRUFE
out_1.jpg
out_ok
1002.jpg
1003.jpg
Click Mode
Image Position Reshuffle
Aligning Direction-Designation
710
711
REDUCTION
ENLARGEMENT
START
CANCEL

FIG. 8

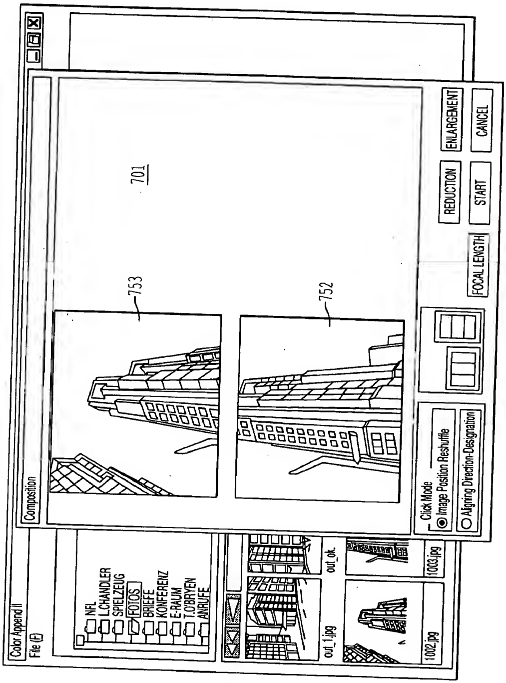

Color Append II
File (F)
NFL
LCHANDLER
SPIELZEUG
FOTOS
BRIEFE
KONFERENZ
E-RAUM
T.O'BRYEN
ANRUFE
out_1.jpg
out_ok.
1002.jpg
1003.jpg
Composition
701
753
752
REDUCTION
ENLARGEMENT
START
CANCEL
FOCAL LENGTH
Click Mode
Image Position Reshuffle
Aligning Direction-Designation

FIG. 9

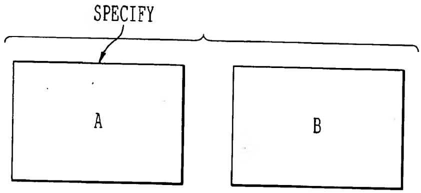


FIG. 10A

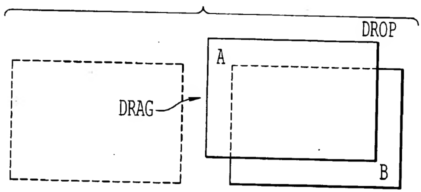


FIG. 10B

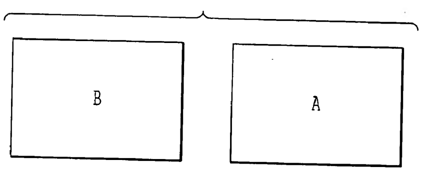


FIG. 10C

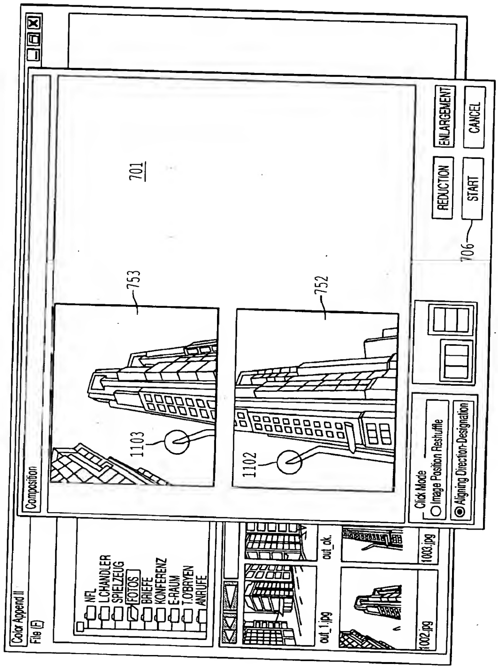

Color Append II
File (F)
NFL
L.CHANDLER
SPIELZEUG
FOTOS
BRIEFE
KONFERENZ
E-RAUM
T.O'BRYEN
ANRUFE
out_1.jpg
out_ok.
1002.jpg
1003.jpg
Composition
701
753
752
1103
1102
706
REDUCTION
ENLARGEMENT
START
CANCEL
Click Mode
Image Position Reshuffle
Aligning Direction-Designation

FIG. 11

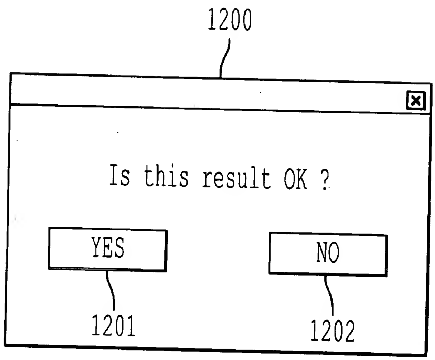


FIG. 12

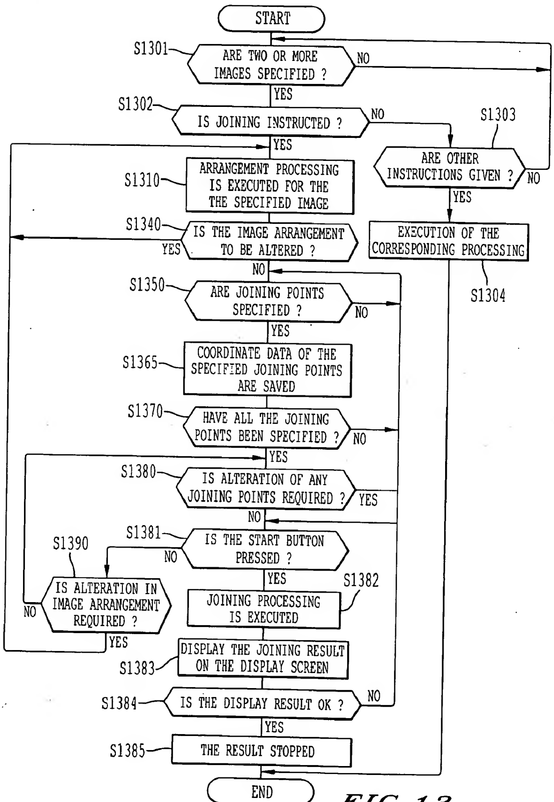

START
S1301
ARE TWO OR MORE IMAGES SPECIFIED ?
NO
YES
S1302
IS JOINING INSTRUCTED ?
NO
S1303
YES
ARE OTHER INSTRUCTIONS GIVEN ?
NO
YES
S1310
ARRANGEMENT PROCESSING IS EXECUTED FOR THE THE SPECIFIED IMAGE
EXECUTION OF THE CORRESPONDING PROCESSING
S1304
S1340
IS THE IMAGE ARRANGEMENT TO BE ALTERED ?
YES
NO
S1350
ARE JOINING POINTS SPECIFIED ?
NO
YES
S1365
COORDINATE DATA OF THE SPECIFIED JOINING POINTS ARE SAVED
S1370
HAVE ALL THE JOINING POINTS BEEN SPECIFIED ?
NO
YES
S1380
IS ALTERATION OF ANY JOINING POINTS REQUIRED ?
YES
NO
S1390
S1381
IS THE START BUTTON PRESSED ?
NO
YES
S1382
IS ALTERATION IN IMAGE ARRANGEMENT REQUIRED ?
NO
YES
JOINING PROCESSING IS EXECUTED
DISPLAY THE JOINING RESULT ON THE DISPLAY SCREEN
S1383
S1384
IS THE DISPLAY RESULT OK ?
NO
YES
S1385
THE RESULT STOPPED
END

FIG. 13

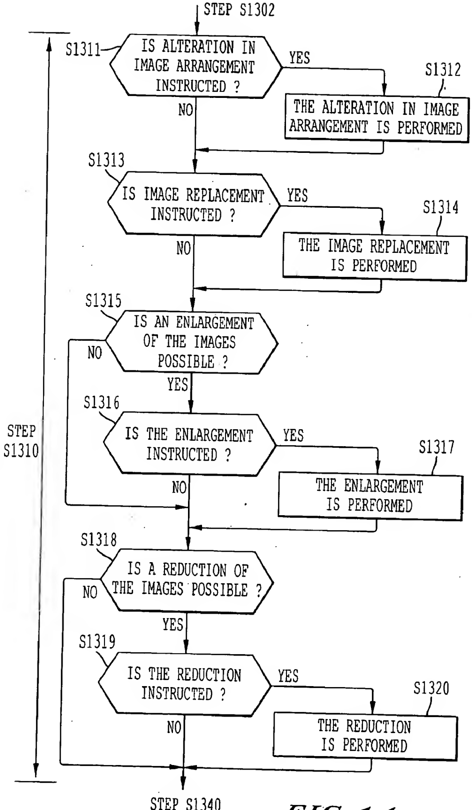

STEP S1302
S1311
IS ALTERATION IN IMAGE ARRANGEMENT INSTRUCTED ?
YES
NO
S1312
THE ALTERATION IN IMAGE ARRANGEMENT IS PERFORMED
S1313
IS IMAGE REPLACEMENT INSTRUCTED ?
YES
NO
S1314
THE IMAGE REPLACEMENT IS PERFORMED
S1315
IS AN ENLARGEMENT OF THE IMAGES POSSIBLE ?
NO
YES
S1316
IS THE ENLARGEMENT INSTRUCTED ?
YES
NO
S1317
THE ENLARGEMENT IS PERFORMED
STEP S1310
S1318
IS A REDUCTION OF THE IMAGES POSSIBLE ?
NO
YES
S1319
IS THE REDUCTION INSTRUCTED ?
YES
NO
S1320
THE REDUCTION IS PERFORMED
STEP S1340

FIG. 14

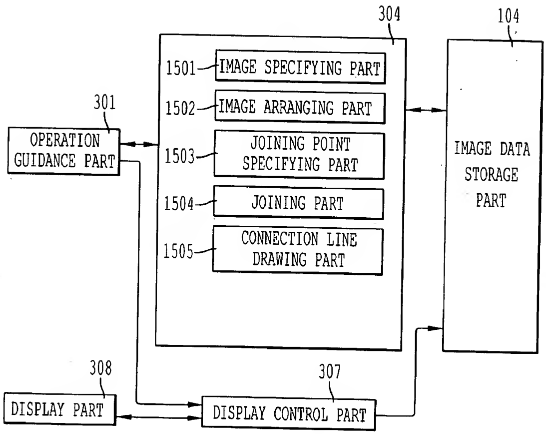

304
104
1501
IMAGE SPECIFYING PART
1502
IMAGE ARRANGING PART
301
OPERATION GUIDANCE PART
1503
JOINING POINT SPECIFYING PART
IMAGE DATA STORAGE PART
1504
JOINING PART
1505
CONNECTION LINE DRAWING PART
308
307
DISPLAY PART
DISPLAY CONTROL PART

FIG. 15

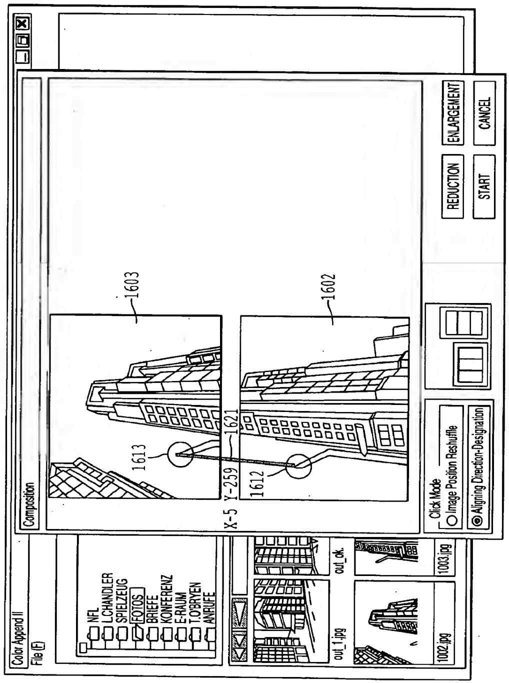

Color Append II
File (F)
NFL
L.CHANDLER
SPIELZEUG
FOTOS
BRIEFE
KONFERENZ
E-RAUM
T.O'BRYEN
ANRUFE
out_1.jpg
out_ok.
1002.jpg
1003.jpg
Composition
1603
1602
1613
1612
1621
X-5 Y-259
Click Mode
Image Position Reshuffle
Aligning Direction-Designation
REDUCTION
ENLARGEMENT
START
CANCEL

FIG. 16

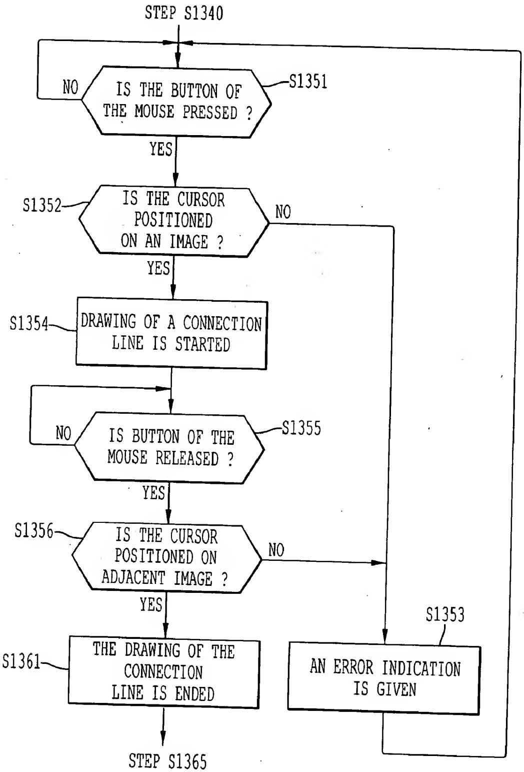

STEP S1340
IS THE BUTTON OF THE MOUSE PRESSED ?
S1351
NO
YES
IS THE CURSOR POSITIONED ON AN IMAGE ?
S1352
NO
YES
DRAWING OF A CONNECTION LINE IS STARTED
S1354
IS BUTTON OF THE MOUSE RELEASED ?
S1355
NO
YES
IS THE CURSOR POSITIONED ON ADJACENT IMAGE ?
S1356
NO
YES
THE DRAWING OF THE CONNECTION LINE IS ENDED
S1361
AN ERROR INDICATION IS GIVEN
S1353
STEP S1365

FIG. 17

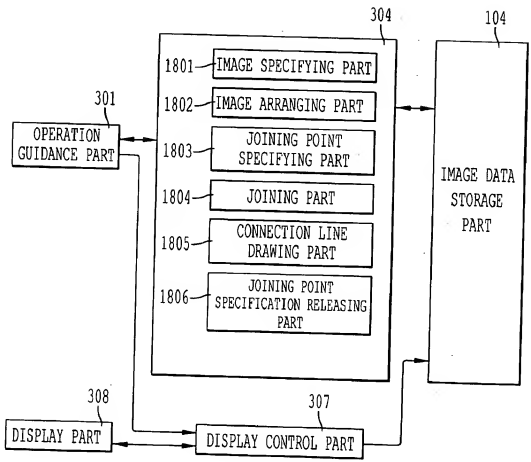

304
104
1801
IMAGE SPECIFYING PART
1802
IMAGE ARRANGING PART
301
OPERATION GUIDANCE PART
1803
JOINING POINT SPECIFYING PART
1804
JOINING PART
1805
CONNECTION LINE DRAWING PART
1806
JOINING POINT SPECIFICATION RELEASING PART
IMAGE DATA STORAGE PART
308
DISPLAY PART
307
DISPLAY CONTROL PART

FIG. 18

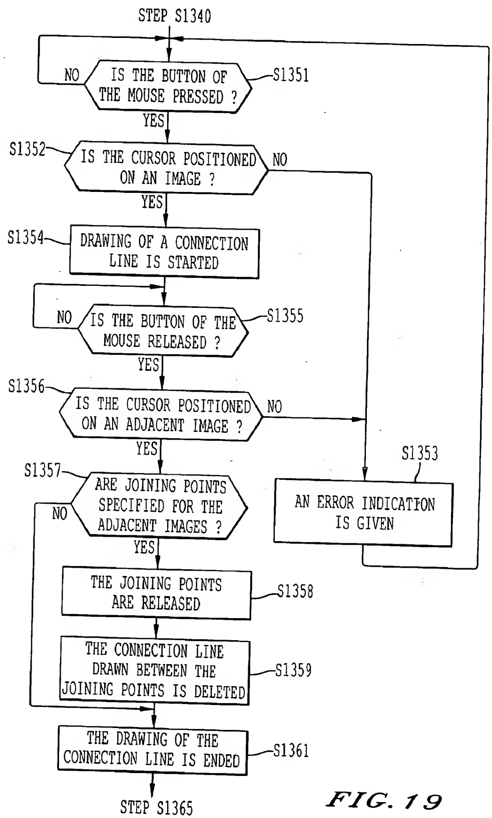

STEP S1340
IS THE BUTTON OF THE MOUSE PRESSED ?
S1351
NO
YES
S1352
IS THE CURSOR POSITIONED ON AN IMAGE ?
NO
YES
S1354
DRAWING OF A CONNECTION LINE IS STARTED
NO
IS THE BUTTON OF THE MOUSE RELEASED ?
S1355
YES
S1356
IS THE CURSOR POSITIONED ON AN ADJACENT IMAGE ?
NO
YES
S1353
AN ERROR INDICATION IS GIVEN
S1357
ARE JOINING POINTS SPECIFIED FOR THE ADJACENT IMAGES ?
NO
YES
THE JOINING POINTS ARE RELEASED
S1358
THE CONNECTION LINE DRAWN BETWEEN THE JOINING POINTS IS DELETED
S1359
THE DRAWING OF THE CONNECTION LINE IS ENDED
S1361
STEP S1365

FIG. 19

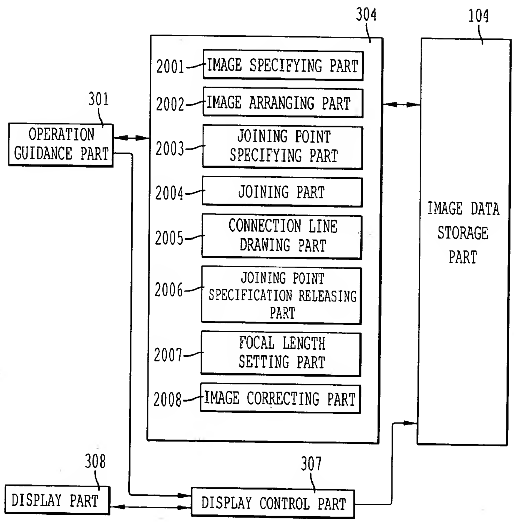

304
104
301
2001 IMAGE SPECIFYING PART
2002 IMAGE ARRANGING PART
OPERATION GUIDANCE PART
2003 JOINING POINT SPECIFYING PART
2004 JOINING PART
2005 CONNECTION LINE DRAWING PART
IMAGE DATA STORAGE PART
2006 JOINING POINT SPECIFICATION RELEASING PART
2007 FOCAL LENGTH SETTING PART
2008 IMAGE CORRECTING PART
308
307
DISPLAY PART
DISPLAY CONTROL PART

FIG. 20

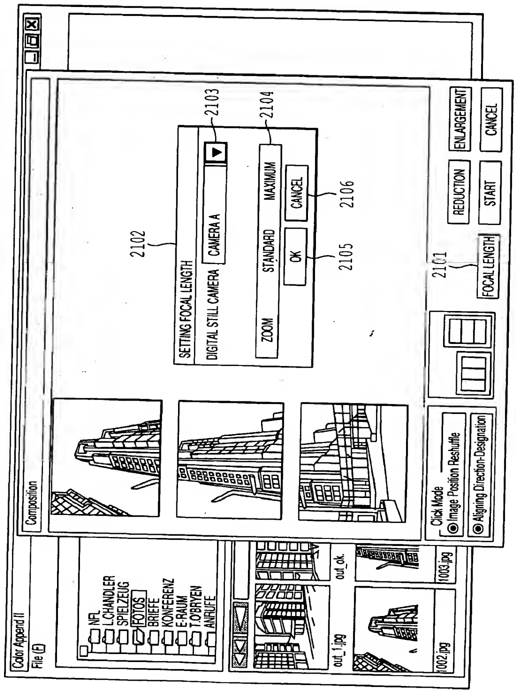

Color Append II
File (F)
NFL
L.CHANDLER
SPIELZEUG
FOTOS
BRIEFE
KONFERENZ
E-RAUM
T.O'BRYEN
ANRUFE
out_1.jpg
out_ok.
1002.jpg
1003.jpg
Composition
SETTING FOCAL LENGTH
DIGITAL STILL CAMERA
CAMERA A
ZOOM
STANDARD
MAXIMUM
OK
CANCEL
2101
2102
2103
2104
2105
2106
FOCAL LENGTH
REDUCTION
ENLARGEMENT
START
CANCEL
Click Mode
Image Position Reshuffle
Aligning Direction-Designation

FIG. 21

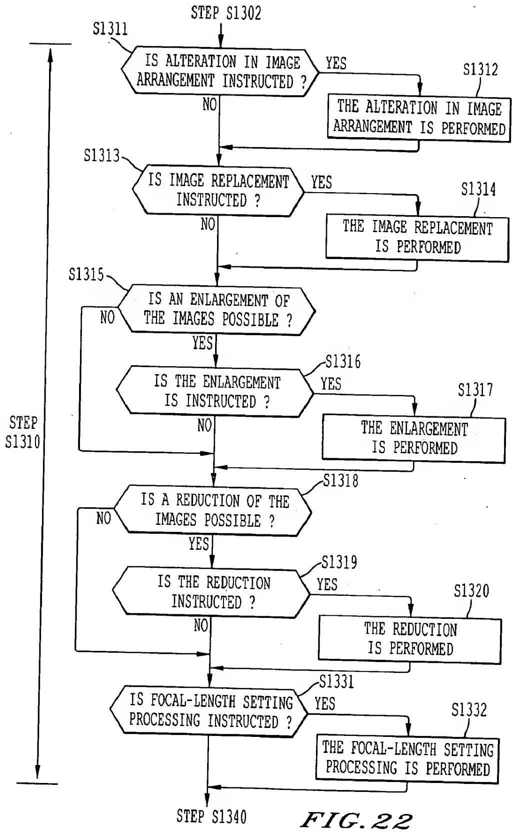

STEP S1302
S1311
IS ALTERATION IN IMAGE ARRANGEMENT INSTRUCTED ?
YES
NO
S1312
THE ALTERATION IN IMAGE ARRANGEMENT IS PERFORMED
S1313
IS IMAGE REPLACEMENT INSTRUCTED ?
YES
NO
S1314
THE IMAGE REPLACEMENT IS PERFORMED
S1315
IS AN ENLARGEMENT OF THE IMAGES POSSIBLE ?
NO
YES
S1316
IS THE ENLARGEMENT IS INSTRUCTED ?
YES
NO
S1317
THE ENLARGEMENT IS PERFORMED
STEP S1310
S1318
IS A REDUCTION OF THE IMAGES POSSIBLE ?
NO
YES
S1319
IS THE REDUCTION INSTRUCTED ?
YES
NO
S1320
THE REDUCTION IS PERFORMED
S1331
IS FOCAL-LENGTH SETTING PROCESSING INSTRUCTED ?
YES
S1332
THE FOCAL-LENGTH SETTING PROCESSING IS PERFORMED
STEP S1340

FIG. 22

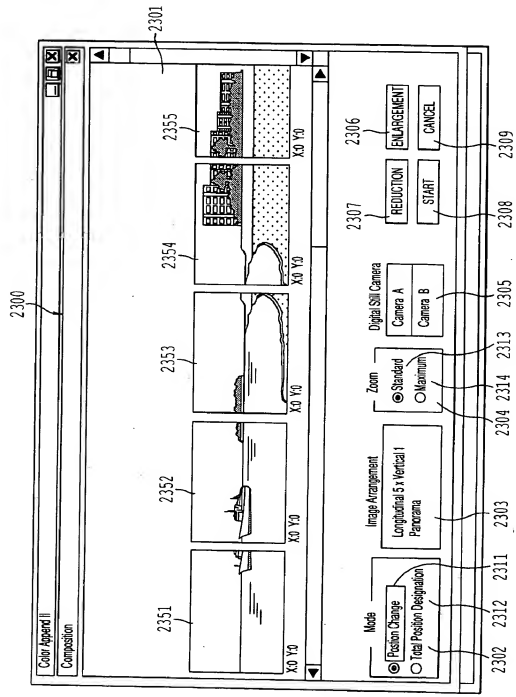

2300
2301
Color Append II
Composition
2351
2352
2353
2354
2355
X:0 Y:0
X:0 Y:0
X:0 Y:0
X:0 Y:0
X:0 Y:0
Mode
Position Change
Total Position Designation
Image Arrangement
Longitudinal 5 x Vertical 1
Panorama
Zoom
Standard
Maximum
Digital Still Camera
Camera A
Camera B
REDUCTION
ENLARGEMENT
START
CANCEL
2306
2307
2302
2312
2311
2303
2304
2314
2313
2305
2308
2309

FIG. 23

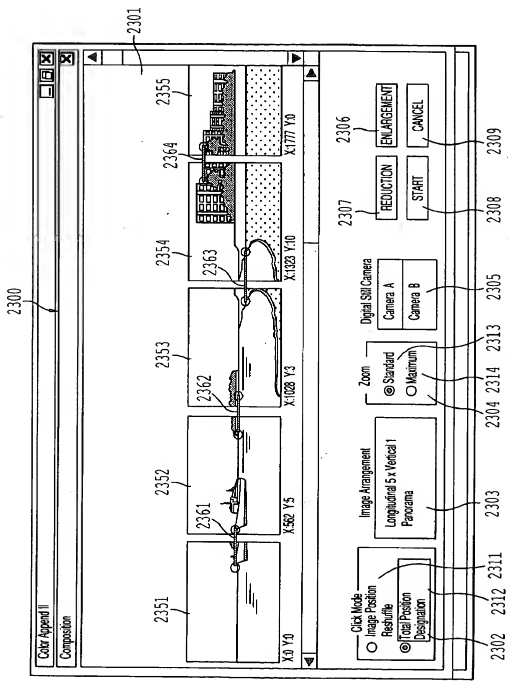

2300
2301
Color Append II
Composition
2351
2352
2353
2354
2355
2361
2362
2363
2364
X:0 Y:0
X:562 Y:5
X:1028 Y:3
X:1323 Y:10
X:1777 Y:0
Click Mode
Image Position Reshuffle
Total Position Designation
Image Arrangement
Longitudinal 5 x Vertical 1 Panorama
Zoom
Standard
Maximum
Digital Still Camera
Camera A
Camera B
REDUCTION
ENLARGEMENT
START
CANCEL
2302
2311
2312
2303
2304
2313
2314
2305
2306
2307
2308
2309

FIG. 24

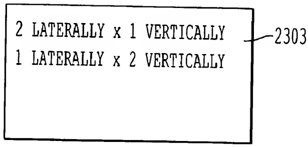


FIG. 25A

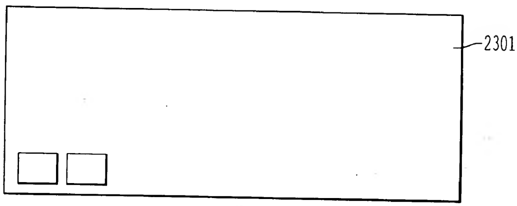


FIG. 25B

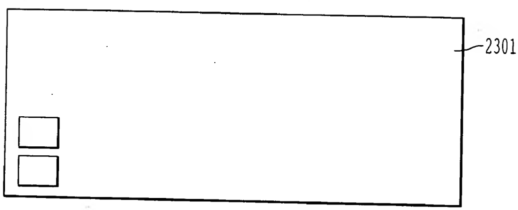


FIG. 25C

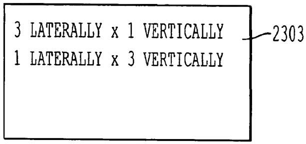


FIG. 26A

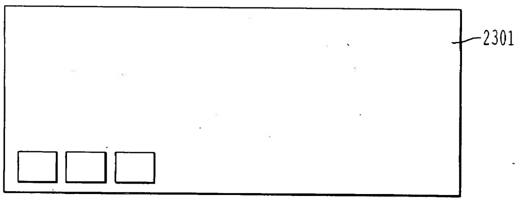


FIG. 26B

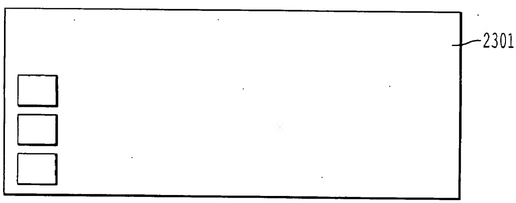


FIG. 26C

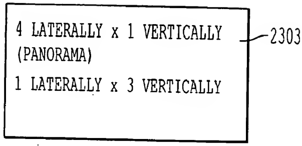


FIG. 27A

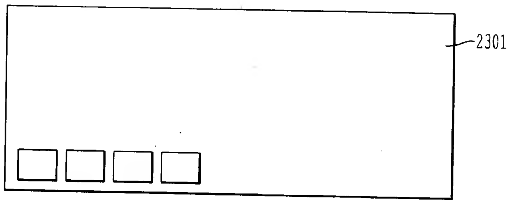


FIG. 27B

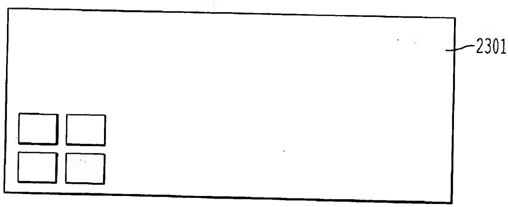


FIG. 27C

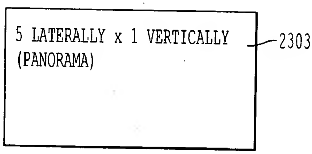


FIG. 28A

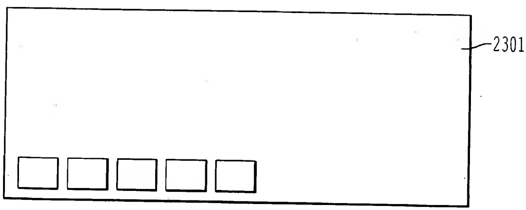


FIG. 28B

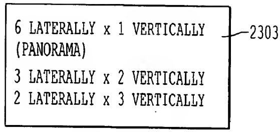


FIG. 29A

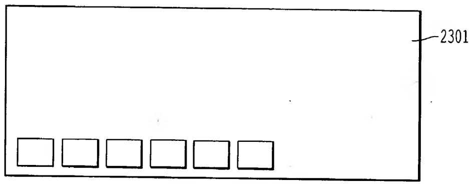


FIG. 29B

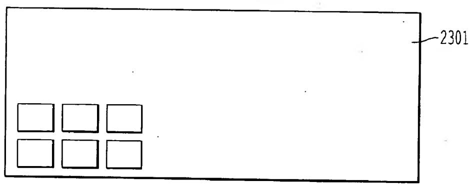


FIG. 29C

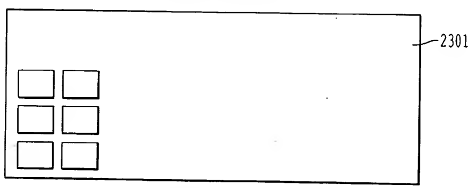


FIG. 29D

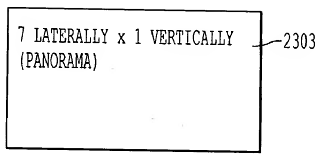


FIG. 30A

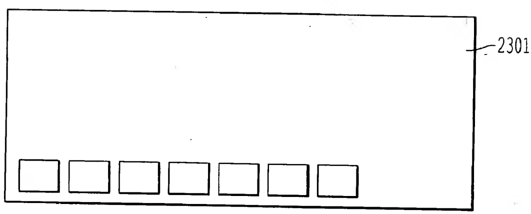


FIG. 30B

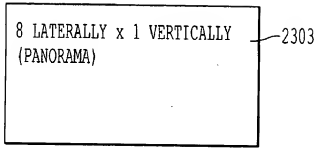


FIG. 31A

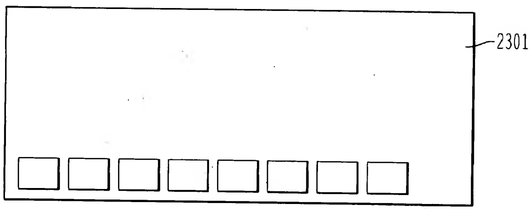


FIG. 31B

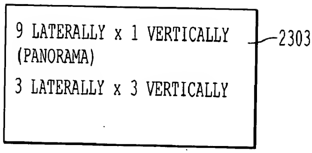


FIG. 32A

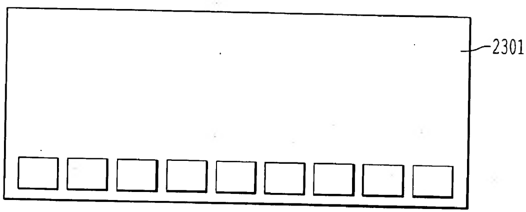


FIG. 32B

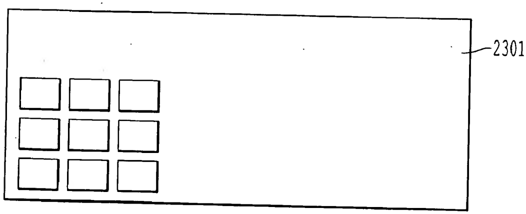


FIG. 32C

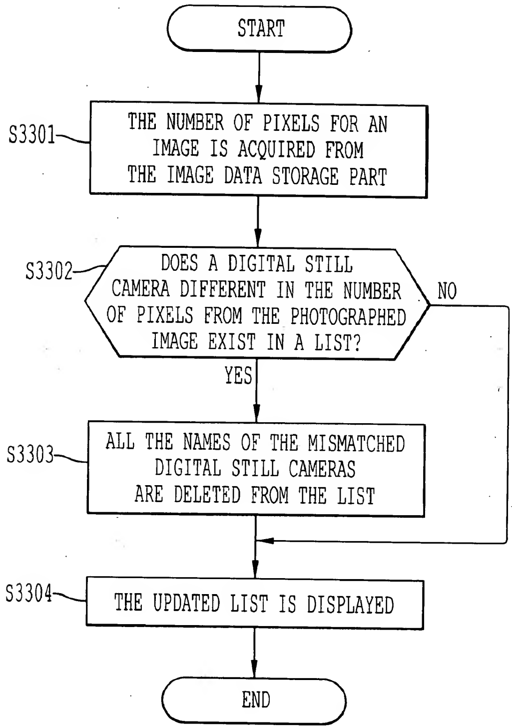

START
S3301
THE NUMBER OF PIXELS FOR AN IMAGE IS ACQUIRED FROM THE IMAGE DATA STORAGE PART
S3302
DOES A DIGITAL STILL CAMERA DIFFERENT IN THE NUMBER OF PIXELS FROM THE PHOTOGRAPHED IMAGE EXIST IN A LIST?
NO
YES
S3303
ALL THE NAMES OF THE MISMATCHED DIGITAL STILL CAMERAS ARE DELETED FROM THE LIST
S3304
THE UPDATED LIST IS DISPLAYED
END

FIG. 33

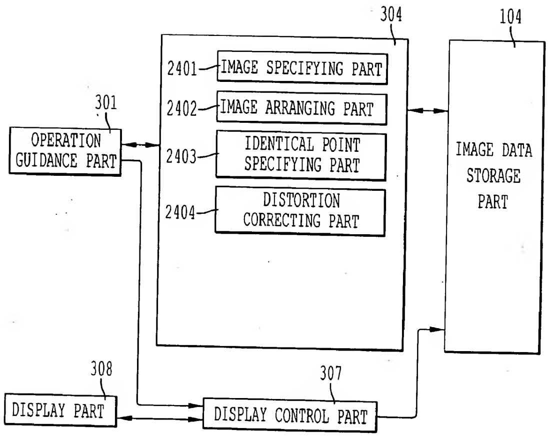
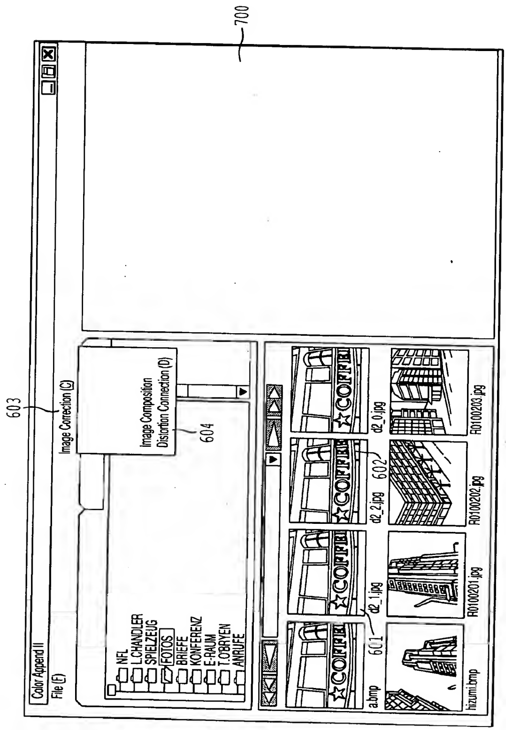

304
104
2401
IMAGE SPECIFYING PART
2402
IMAGE ARRANGING PART
301
OPERATION GUIDANCE PART
2403
IDENTICAL POINT SPECIFYING PART
IMAGE DATA STORAGE PART
2404
DISTORTION CORRECTING PART
308
307
DISPLAY PART
DISPLAY CONTROL PART

FIG. 34



700
603
Color Append II
File (F)
Image Correction (C)
Image Composition
Distortion Connection (D)
604
NFL
L.CHANDLER
SPIELZEUG
FOTOS
BRIEFE
KONFERENZ
E-RAUM
T.O'BRYEN
ANRUFE
601
602
a.bmp
d2_1.jpg
d2_2.jpg
d2_0.jpg
hizumi.bmp
R0100201.jpg
R0100202.jpg
R0100203.jpg

FIG. 35

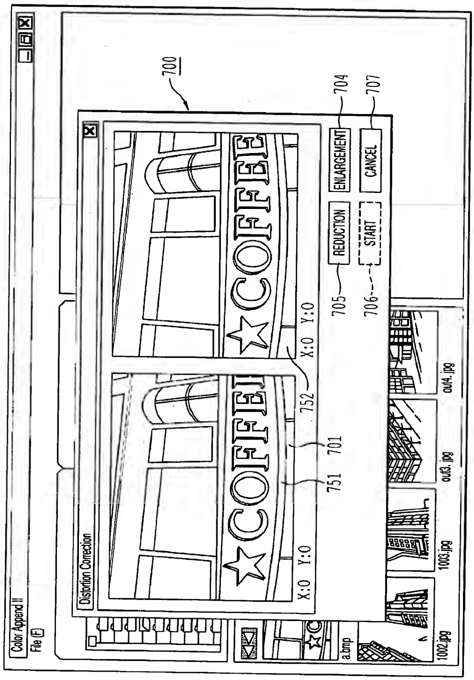

Color Append II
File (F)
Distortion Correction
700
COFFEE
X:0 Y:0
X:0 Y:0
751
701
752
705
REDUCTION
ENLARGEMENT
704
706
START
CANCEL
707
a.bmp
1002.jpg
1003.jpg
out3.jpg
out4.jpg

FIG. 36

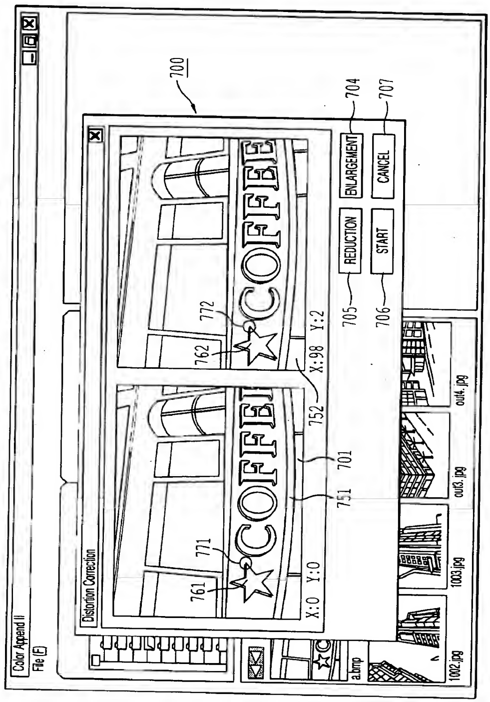

Color Append II
File (F)
Distortion Correction
COFFEE
X:0 Y:0
X:98 Y:2
REDUCTION
ENLARGEMENT
START
CANCEL
a.bmp
1002.jpg
1003.jpg
out3.jpg
out4.jpg
700
701
704
705
706
707
751
752
761
762
771
772

FIG. 37

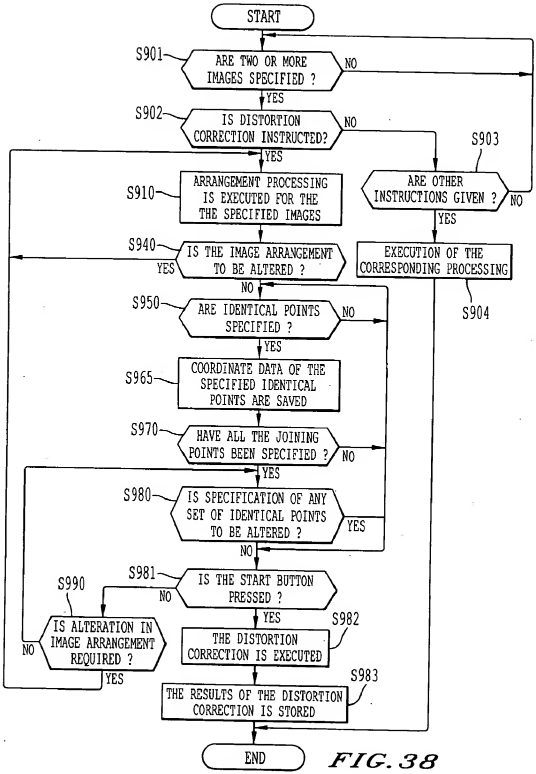

START
S901
ARE TWO OR MORE IMAGES SPECIFIED ?
NO
YES
S902
IS DISTORTION CORRECTION INSTRUCTED?
NO
YES
S903
ARE OTHER INSTRUCTIONS GIVEN ?
NO
YES
S910
ARRANGEMENT PROCESSING IS EXECUTED FOR THE THE SPECIFIED IMAGES
EXECUTION OF THE CORRESPONDING PROCESSING
S904
S940
IS THE IMAGE ARRANGEMENT TO BE ALTERED ?
YES
NO
S950
ARE IDENTICAL POINTS SPECIFIED ?
NO
YES
S965
COORDINATE DATA OF THE SPECIFIED IDENTICAL POINTS ARE SAVED
S970
HAVE ALL THE JOINING POINTS BEEN SPECIFIED ?
NO
YES
S980
IS SPECIFICATION OF ANY SET OF IDENTICAL POINTS TO BE ALTERED ?
YES
NO
S981
IS THE START BUTTON PRESSED ?
NO
YES
S990
IS ALTERATION IN IMAGE ARRANGEMENT REQUIRED ?
NO
YES
S982
THE DISTORTION CORRECTION IS EXECUTED
S983
THE RESULTS OF THE DISTORTION CORRECTION IS STORED
END

FIG. 38

FIG. 39

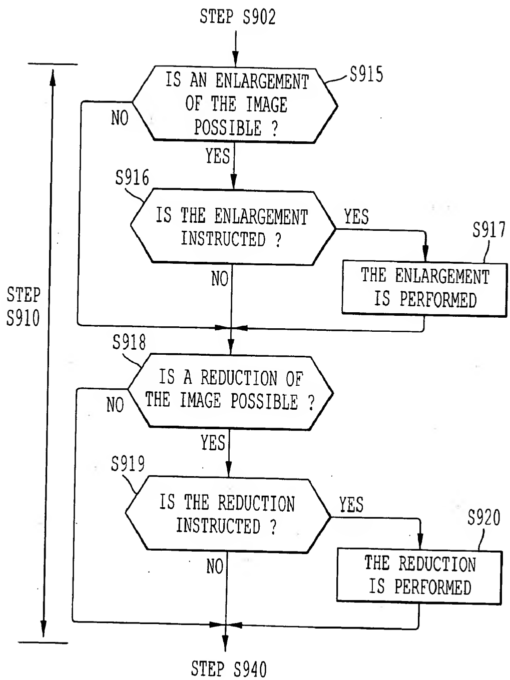

STEP S902
IS AN ENLARGEMENT OF THE IMAGE POSSIBLE ?
S915
NO
YES
S916
IS THE ENLARGEMENT INSTRUCTED ?
YES
S917
THE ENLARGEMENT IS PERFORMED
NO
STEP S910
S918
IS A REDUCTION OF THE IMAGE POSSIBLE ?
NO
YES
S919
IS THE REDUCTION INSTRUCTED ?
YES
S920
THE REDUCTION IS PERFORMED
NO
STEP S940

FIG. 40

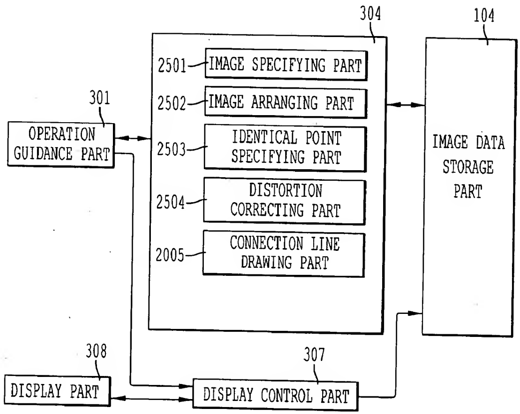

304
104
2501
IMAGE SPECIFYING PART
2502
IMAGE ARRANGING PART
301
OPERATION GUIDANCE PART
2503
IDENTICAL POINT SPECIFYING PART
IMAGE DATA STORAGE PART
2504
DISTORTION CORRECTING PART
2005
CONNECTION LINE DRAWING PART
308
307
DISPLAY PART
DISPLAY CONTROL PART

FIG. 41

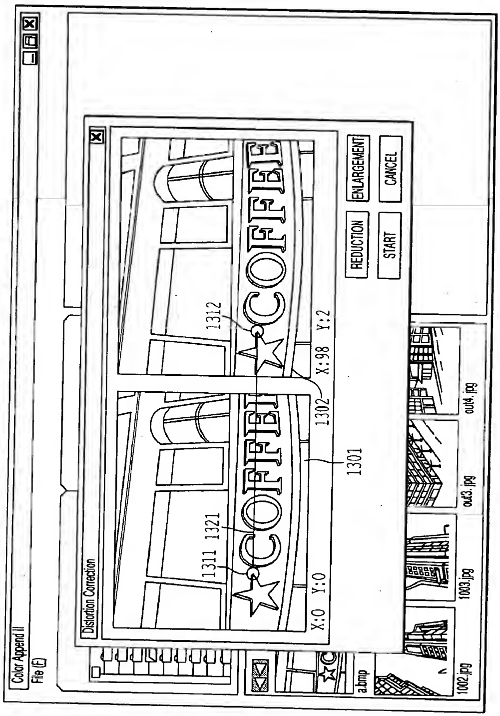

Color Append II
File (F)
Distortion Correction
REDUCTION
ENLARGEMENT
START
CANCEL
1311
1321
1312
1302
1301
X:0 Y:0
X:98 Y:2
a.bmp
1002.jpg
1003.jpg
out3.jpg
out4.jpg

FIG. 42

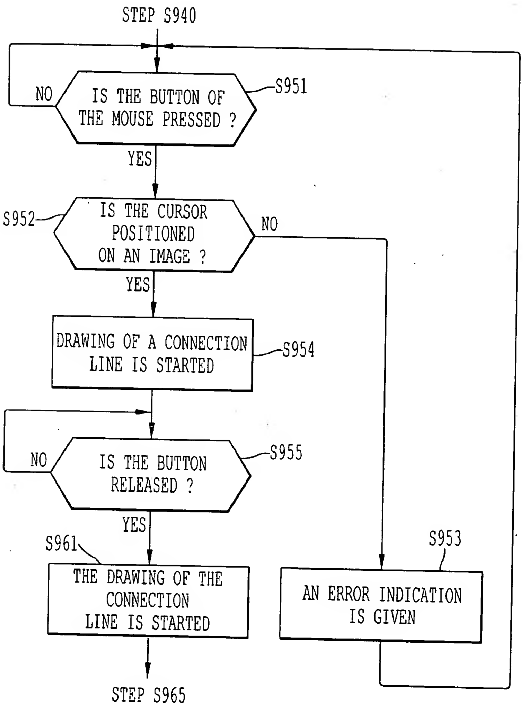

STEP S940
IS THE BUTTON OF THE MOUSE PRESSED ?
S951
NO
YES
IS THE CURSOR POSITIONED ON AN IMAGE ?
S952
NO
YES
DRAWING OF A CONNECTION LINE IS STARTED
S954
IS THE BUTTON RELEASED ?
S955
NO
YES
S961
THE DRAWING OF THE CONNECTION LINE IS STARTED
S953
AN ERROR INDICATION IS GIVEN
STEP S965

FIG. 43

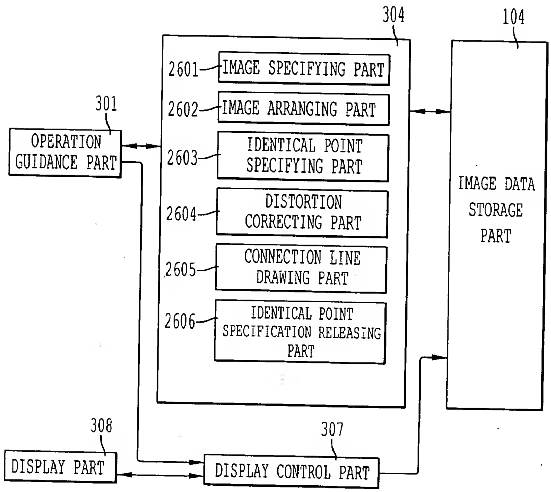

304
104
2601
IMAGE SPECIFYING PART
2602
IMAGE ARRANGING PART
301
OPERATION GUIDANCE PART
2603
IDENTICAL POINT SPECIFYING PART
2604
DISTORTION CORRECTING PART
2605
CONNECTION LINE DRAWING PART
2606
IDENTICAL POINT SPECIFICATION RELEASING PART
IMAGE DATA STORAGE PART
308
DISPLAY PART
307
DISPLAY CONTROL PART

FIG. 44

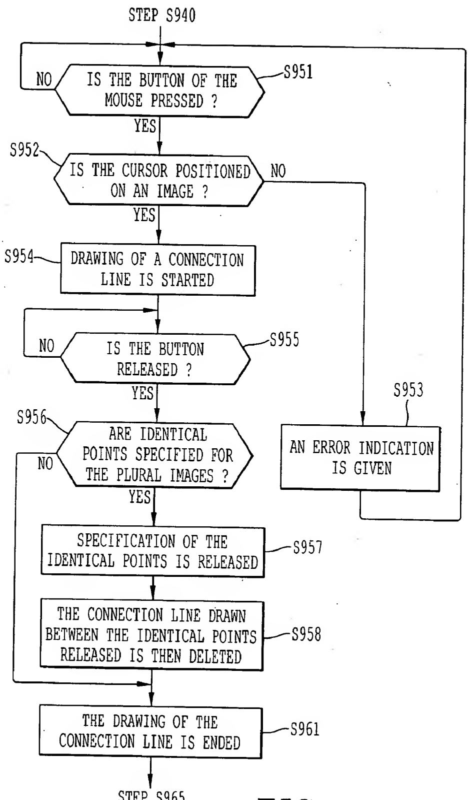

STEP S940
IS THE BUTTON OF THE MOUSE PRESSED ?
S951
NO
YES
S952
IS THE CURSOR POSITIONED ON AN IMAGE ?
NO
YES
S954
DRAWING OF A CONNECTION LINE IS STARTED
IS THE BUTTON RELEASED ?
S955
NO
YES
S953
AN ERROR INDICATION IS GIVEN
S956
ARE IDENTICAL POINTS SPECIFIED FOR THE PLURAL IMAGES ?
NO
YES
SPECIFICATION OF THE IDENTICAL POINTS IS RELEASED
S957
THE CONNECTION LINE DRAWN BETWEEN THE IDENTICAL POINTS RELEASED IS THEN DELETED
S958
THE DRAWING OF THE CONNECTION LINE IS ENDED
S961
STEP S965

FIG. 45

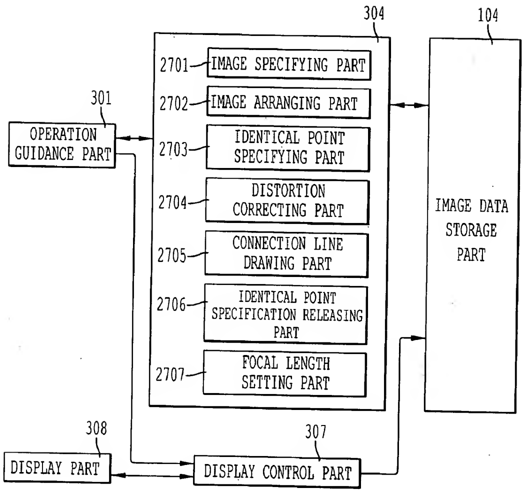

304
104
301
2701
IMAGE SPECIFYING PART
2702
IMAGE ARRANGING PART
OPERATION GUIDANCE PART
2703
IDENTICAL POINT SPECIFYING PART
2704
DISTORTION CORRECTING PART
2705
CONNECTION LINE DRAWING PART
2706
IDENTICAL POINT SPECIFICATION RELEASING PART
2707
FOCAL LENGTH SETTING PART
IMAGE DATA STORAGE PART
308
307
DISPLAY PART
DISPLAY CONTROL PART

FIG. 46

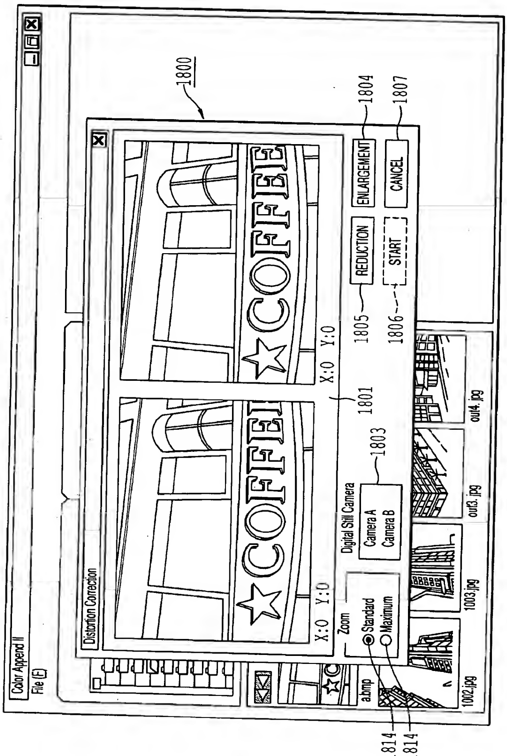

1800
Color Append II
File (F)
Distortion Correction
X:0 Y:0
X:0 Y:0
1801
COFFEE
Zoom
Standard
Maximum
Digital Still Camera
Camera A
Camera B
1803
REDUCTION
1805
ENLARGEMENT
1804
START
1806
CANCEL
1807
a.bmp
1002.jpg
1003.jpg
out3.jpg
out4.jpg
1814
1814

FIG. 47

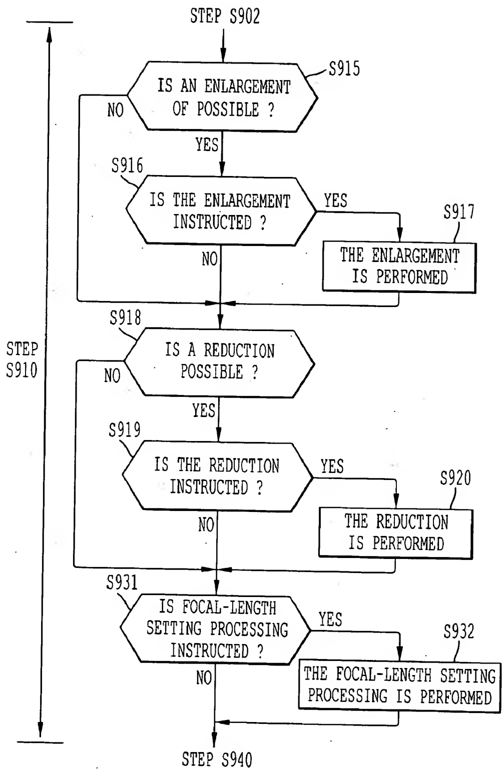

STEP S902
S915
IS AN ENLARGEMENT OF POSSIBLE ?
NO
YES
S916
IS THE ENLARGEMENT INSTRUCTED ?
YES
S917
THE ENLARGEMENT IS PERFORMED
NO
S918
STEP S910
IS A REDUCTION POSSIBLE ?
NO
YES
S919
IS THE REDUCTION INSTRUCTED ?
YES
S920
THE REDUCTION IS PERFORMED
NO
S931
IS FOCAL-LENGTH SETTING PROCESSING INSTRUCTED ?
YES
S932
THE FOCAL-LENGTH SETTING PROCESSING IS PERFORMED
NO
STEP S940

FIG. 48

IMAGE PROCESSING APPARATUS, METHOD AND COMPUTER-READABLE RECORDING MEDIUM WITH PROGRAM RECORDED THEREON, FOR JOINING IMAGES TOGETHER BY USING VISIBLE JOINING POINTS AND CORRECTING IMAGE DISTORTION EASILY

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to image processing apparatus and method to display images on a display screen, edit and process the images displayed, and retrieve the images edited and processed, and a computer-readable recording medium with a program thereon for making the computer execute the method. In particular, the invention relates to a technique for joining plural images and correcting distortion of the images.

2. Discussion of the Background

There has conventionally been known a technique for joining plural images together to form an image picture. Such a technique would be used in a case where two or more images are necessary to photograph a panoramic view, such as the entire image of a tall building or an event hall, an aerial photograph or a case where the distance from an object to be photographed is too near for a normal digital still camera to put the entire image in a picture, such as an interior photo. In these cases, two or more pictures need to be joined with each other to form the panoramic view. A method of joining two images has been known in which two images are joined with each other by moving and putting either of the images in position by hand while viewing the joining part on a screen.

It is known that an image photographed by a digital still camera or video camera generally contains geometrical distortion produced by distortion aberration of the lens system forming the image in a position deviated from the original position. To correct distortion of such an image, a method is known such as one disclosed in Japanese patent application laid-open publication No. 9-294225, entitled "Method for Deciding Parameter for Image Distortion Correction and Image Pickup Device." This publication discloses a technique in which plural images including a common pattern picked up from one point are used to detect plural sets of corresponding observing points from these images and measure angles of the observation points with respect to an optical axis of the image pickup system, thus estimating a parameter for distortion correction based on the angle information obtained.

The above method of joining plural images together to form an image picture may be useful for skilled persons who are specialized in this work, but it is very hard for beginners to do these jobs efficiently. If two or more images are joined together to form an image picture, adjacent images need to be adjusted one after the other, respectively, and this makes it difficult even for skilled persons to do this work efficiently. It is also necessary to perform additional image correction so as to make the joining part inconspicuous. When the images are joined by hand, the image correction must also be performed by hand, and this results in a reduction in operation efficiency.

Image distortion correction requires detection of plural sets of corresponding observing points from images, the distortion of which should be corrected. It may be possible for skilled persons to detect observing points and input data related to the observing points, but it is very hard for beginners to do these jobs efficiently. When image distortion correction needs to be performed for a large number of images, detection of observing points and data input of the observing points are required for each image. This makes it difficult even for skilled persons to do these jobs efficiently.

SUMMARY OF THE INVENTION

In order to solve the above conventional problems, an object of the present invention is to provide an image processing apparatus and method capable of joining plural images in an easy operation even for beginners, and a computer-readable recording medium with a program recorded thereon for making the computer execute the method.

Another object of the present invention is to provide image processing apparatus and method capable of correcting distortion of images in an easy operation even for beginners, and a computer-readable recording medium with a program recorded thereon for making the computer execute the method.

In one aspect of the present invention, an image processing apparatus is provided with a display device to display images on a display screen so that the images displayed on the display device can be edited and processed for smooth joining of the images. The image processing apparatus includes an image specifying device to specify two or more images to be joined together on the display device. An image arranging device arranges the images specified by the image specifying device in such an order as to join the images together, and a display control device controls the display device to display the images arranged by the image arranging device. A joining point specifying device specifies a joining point for each image so that vertically or laterally adjacent images displayed by the display control device can be joined together by referring to the joining points. A joining device joins adjacent images together by referring to the joining points specified by the joining point specifying device. According to the present invention, the specified images are arranged in such an order as to be joined together, and the arranged images are so displayed that a joining point can be specified for each image while viewing both images displayed adjacent to each other. This makes it possible to easily join the images together by merely specifying one joining point for each image, and hence to execute editing and processing of the images such as image joining easily and efficiently.

In another aspect of the present invention, the image processing apparatus further includes a connection line drawing device to draw a connection line between joining points specified by the joining point specifying device, and the display control device controls the display device to display both the images arranged by the image arranging device and the connection line drawn by the connection line drawing device. According to the present invention, a connection line is drawn between the joining points specified, so that the operator can both specify the joining points as if he or she drew a line by hand, and recognize instantaneously whether the joining points are specified or not.

In still another aspect of the present invention, the image processing apparatus further includes a joining-point specification releasing device to release specification of the previously specified set of joining points when a given set of joining points is specified for a pair of adjacent images. According to the invention, when a set of joining points is specified for a pair of adjacent images for which another set

of joining points has already been specified, specification of the previous set of joining points is released, so that when specifying a new set of joining points, the operator can change the specification of joining points easily and efficiently in the same operation as when specifying a set of joining points for the first time, without the need to release the specification of the previous set of joining points.

In yet another aspect of the present invention, the image processing apparatus further includes a focal length setting device to set the focal length with which an image has been input, and an image correcting device to correct the image based on the focal length set by the focal length setting device. According to the invention, the focal length with which an image has been input is set to correct the image based on the focal length set for joining the image with another. This makes it possible to join images without distortion, even if the images have been input by input devices with different focal lengths.

In still another aspect of the present invention, a method for controlling an image processing apparatus for joining of images includes steps of displaying images on a display screen, specifying two or more images to be joined together, arranging the specified images in such an order as to be joined together, displaying the arranged images, specifying a joining point for each image so that adjacent images displayed can be joined by referring to the joining points, and joining adjacent images together by referring to the specified joining point. According to the invention, the specified images are arranged in such an order as to be joined together, and the arranged images are so displayed that a joining point can be specified for each image while viewing both images displayed adjacent to each other. This makes it possible to join the images by a simple operation of specifying one joining point for each image, and hence to execute editing and processing of the images, such as image joining, easily and efficiently.

In still another aspect of the present invention, the method for joining of images further includes steps of drawing a connection line between the specified joining points, and displaying not only the arranged images but also the drawn connection line. According to the invention, a connection line is drawn between the joining points specified, so that the operator can specify both the joining points as if he or she drew a line by hand, and recognize instantaneously whether the joining points are specified or not.

In yet another aspect of the present invention, the method for joining of images further includes a step of releasing specification of the previously specified set of joining points when a new set of joining points is specified. According to the invention, when a set of joining points is specified for a pair of adjacent images for which another set of joining points has already been specified. specification of the previous set of joining points is released, so that when specifying a new set of joining points, the operator can change the specification of joining points easily and efficiently in the same operation as when specifying a set of joining points for the first time, without the need to release the specification of the previous set of joining points.

In yet another aspect of the present invention, the method for joining of images further includes a step of setting the focal length with which an image has been input, and a step of correcting the image based on the focal length set for use in joining the image with another. According to the invention, the focal length with which an image has been input is set to correct the image based on the focal length set for joining the image with another. This makes it possible to join images without occurrence of distortion even if the images have been input by input devices with different focal lengths.

In yet another aspect of the present invention, a computer readable recording medium stores computer instructions for controlling an image processing apparatus for joining of images by performing the above-described steps. This makes it possible for a computer to read the computer instructions, and hence for the computer to carry out the method for controlling an image processing apparatus for the joining of images.

In still another aspect of the present invention, an image processing apparatus is provided with a display device for displaying images on a display screen so that the images displayed on the display device can be edited and processed for correction of image distortion. An image specifying device specifies at least two images which are photographed at slightly different photographing positions for correcting distortion of the images. An image arranging device arranges the images specified by the image specifying device, and a display control device controls the display device to display the images arranged by the image arranging device. An identical point specifying device specifies an identical point for each image displayed by the display control device, and a distortion correcting device corrects distortion of images by referring to the identical points specified by the identical point specifying device. According to the invention, image distortion can be corrected by a simple operation to merely specify one identical point for each image displayed, thus editing and processing the images easily and efficiently.

In yet another aspect of the present invention, the image processing apparatus for correction of image distortion further includes a connection line drawing device to draw a connection line between identical points specified by the identical point specifying device, and the display control device controls the display device to display both the images arranged by the image arranging device and the connection line drawn by the connection line drawing device. According to the invention, a connection line is drawn between the identical points specified, so that the operator can specify the identical points as if he or she drew a line by hand, and recognize instantaneously whether the identical points are specified or not.

In still another aspect of the present invention, the image processing apparatus for correction of image distortion further includes an identical point specification releasing device to release specification of the previously set of identical points when a new set of identical points is specified for images for which another set of identical points has already been specified. According to the invention, when a set of identical points is specified for images for which another set of identical points has already been specified specification of the previous set of identical points is released, so that when specifying a new set of identical points, the operator can change the specification of identical points easily and efficiently in the same operation as when specifying a set of identical points for the first time without the need to release the specification of the previous set of identical points.

In still another aspect of the present invention the image processing apparatus for correction of image distortion further includes a focal length setting device to set a focal length with which an image has been input, and the distortion correcting device corrects distortion of the image based on the focal length set by the focal length setting device.

According to the invention, the focal length with which an image has been input is set to correct distortion of the image based on the focal length set. This makes it possible to perform proper distortion correction of images even if the images have been input by input devices with different focal lengths.

In yet another aspect of the present invention, a method for controlling an image processing apparatus for correction of image distortion includes steps of displaying images on a display screen, specifying at least two images photographed at slightly different photographing positions, for correcting distortion of the images, arranging the images specified in the image specifying step, controlling display of the images arranged in the image arranging step, specifying an identical point for each image displayed in the display control step, and correcting distortion of the images by referring to the identical points specified in the identical point specifying step. According to the invention, image distortion can be corrected by a simple operation to merely specify one identical point for each image displayed, thus editing and processing the images easily and efficiently.

In yet another aspect of the present invention, the method for correction of image distortion further includes a step of drawing a connection line between identical points specified in the identical point specifying step, and the display control step controls display of both the images arranged in the image arranging step and the connection line drawn in the connection line drawing step. According to the invention, a connection line is drawn between the identical points specified, so that the operator can both specify the identical points as if he or she drew a line by hand, and recognize instantaneously whether the identical points are specified or not.

In still another aspect of the present invention, the method for correction of image distortion further includes a step of releasing specification of the previous set of identical points when a set of identical points is specified for images for which another set of identical points has already been specified. According to the invention, when a set of identical points is specified for images for which another set of identical points has already been specified, specification of the previous set of identical points is released, so that when specifying a new set of identical points, the operator can change the specification of identical points easily and efficiently in the same operation as when specifying a set of identical points for the first time without the need to release the specification of the previous set of identical points.

In still another aspect of the present invention, the image processing method for image distortion correction further includes a step of setting a focal length with which an image has been input, and the distortion correcting step corrects distortion of the image based on the focal length set in the focal length setting step. According to the invention, the focal length with which an image has been input is set to correct distortion of the image based on the focal length set. This makes it possible to perform proper distortion correction of images even if the images have been input by input devices with different focal lengths.

In still another aspect of the present invention, a computer readable recording medium stores computer instructions for controlling an image processing apparatus for image distortion correction by performing the above-described steps. This makes it possible for a computer to read the instructions mechanically, and hence for the computer to carry out the method for controlling an image processing apparatus for the image distortion correction.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an illustration functionally showing the general structure of an illustrated document creating system including an image processing apparatus according to the present invention commonly used for joining plural images together and correcting distortion of the images;

FIG. **2** is a block diagram showing the hardware configuration of the image processing apparatus according to the present invention commonly used for joining plural images together and correcting distortion of the images;

FIG. **3** is a functional block diagram showing the structure of the image processing apparatus according to the present invention commonly used for joining plural images together and correcting distortion of the images;

FIG. **4** is a functional block diagram showing the arrangement of an image altering part and the surroundings in the image processing apparatus according to the first embodiment of the present invention for the operation of joining plural images;

FIG. **5** is an illustration showing an example of a display screen on a display part of the image processing apparatus according to the first embodiment of the present invention during the operation of joining plural images;

FIG. **6** is an illustration showing another example of the display screen on the display part of the image processing apparatus according to the first embodiment of the present invention during the operation of joining plural images;

FIG. **7** is an illustration showing still another example of the display screen on the display part of the image processing apparatus according to the first embodiment of the present invention during the operation of joining plural images;

FIG. **8** is an illustration showing yet another example of the display screen on the display part of the image processing apparatus according to the first embodiment of the present invention during the operation of joining plural images;

FIG. **9** is an illustration showing yet another example of the display screen on the display part of the image processing apparatus according to the first embodiment of the present invention during the operation of joining plural images;

FIGS. **10*a*–10*c*** are illustrations for explaining image position replacement executed by an image arranging part of the image processing apparatus according to the first embodiment of the present invention during the operation of joining plural images;

FIG. **11** is an illustration showing yet another example of the display screen on the display part of the image processing apparatus according to the first embodiment of the present invention during the operation of joining plural images;

FIG. **12** is an illustration for explaining an example of a window displayed on the display part of the image processing apparatus according to the first embodiment of the present invention during the operation of joining plural images;

FIG. **13** is a flowchart showing a sequence of processing steps executed by the image altering part and a display control part according to the first embodiment of the present invention during the operation of joining plural images;

FIG. **14** is a flowchart showing processing steps executed by the image arranging part according to the first embodiment of the present invention during the operation of joining plural images;

FIG. **15** is a functional block diagram showing the arrangement of an image altering part and the surroundings in an image processing apparatus according to the second embodiment of the present invention during the operation of joining plural images;

FIG. **16** is an illustration showing an example of a display screen on the display part of the image processing apparatus according to the second embodiment of the present invention during the operation of joining plural images;

FIG. **17** is a flowchart showing part of processing steps executed by an image altering part and a display control part according to the second embodiment of the present invention during the operation of joining plural images;

FIG. **18** is a functional block diagram showing the arrangement of an image altering part and the surroundings in an image processing apparatus according to the third embodiment of the present invention during the operation of joining plural images;

FIG. **19** is a flowchart showing parts of processing steps executed by the image altering part and a display control part according to the third embodiment of the present invention during the operation of joining plural images;

FIG. **20** is a functional block diagram showing the arrangement of an image altering part and the surroundings in an image processing apparatus according to the fourth embodiment of the present invention during the operation of joining plural images;

FIG. **21** is an illustration showing an example of a display screen on the display part of the image processing apparatus according to the fourth embodiment of the present invention during the operation of joining plural images;

FIG. **22** is a flowchart showing parts of processing steps executed by the image altering part and a display control part according to the fourth embodiment of the present invention during the operation of joining plural images;

FIG. **23** is an illustration showing an example of a display screen on a display part of an image processing apparatus according to the fifth embodiment of the present invention during the operation of joining plural images;

FIG. **24** is an illustration showing another example of the display screen on the display part of the image processing apparatus according to the fifth embodiment of the present invention during the operation of joining plural images;

FIGS. **25***a*–**25***c* are illustrations showing an example of display on an arrangement switching part and variations of image arrangement in a joining work area of the image processing apparatus according to the fifth embodiment of the present invention during the operation of joining plural images;

FIGS. **26***a*–**26***c* are illustrations showing another example of display on the arrangement switching part and variations of image arrangement in the joining work area of the image processing apparatus according to the fifth embodiment of the present invention during the operation of joining plural images;

FIGS. **27***a*–**27***c* are illustrations showing still another example of display on the arrangement switching part and variations of image arrangement in the joining work area of the image processing apparatus according to the fifth embodiment of the present invention during the operation of joining plural images;

FIGS. **28***a*–**28***b* are illustrations showing yet another example of display on the arrangement switching part and variations of image arrangement in the joining work area of the image processing apparatus according to the fifth embodiment of the present invention during the operation of joining plural images;

FIGS. **29***a*–**29***d* are illustrations showing yet another example of display on the arrangement switching part and variations of image arrangement in the joining work area of the image processing apparatus according to the fifth embodiment of the present invention during the operation of joining plural images.

FIGS. **30***a*–**30***b* are illustrations showing yet another example of display on the arrangement switching part and variations of image arrangement in the joining work area of the image processing apparatus according to the fifth embodiment of the present invention during the operation of joining plural images;

FIGS. **31***a*–**31***b* are illustrations showing yet another example of display on the arrangement switching part and variations of image arrangement in the joining work area of the image processing apparatus according to the fifth embodiment of the present invention during the operation of joining plural images;

FIGS. **32***a*–**32***c* are illustrations showing yet another example of display on the arrangement switching part and variations of image arrangement in the joining work area of the image processing apparatus according to the fifth embodiment of the present invention during the operation of joining plural images;

FIG. **33** is a flowchart showing processing steps of switching the camera mode in the image processing apparatus according to the fifth embodiment of the present invention during the operation of joining plural images;

FIG. **34** is a functional block diagram showing the arrangement of an image altering part and the surroundings in an image processing apparatus according to the sixth embodiment of the present invention during the operation of correcting distortion of images;

FIG. **35** is an illustration showing an example of a display screen on a display part of the image processing apparatus according to the sixth embodiment of the present invention during the operation of correcting distortion of images;

FIG. **36** is an illustration showing another example of the display screen on the display part of the image processing apparatus according to the sixth embodiment of the present invention during the operation of correcting distortion of images;

FIG. **37** is an illustration showing still another example of the display screen on the display part of the image processing apparatus according to the sixth embodiment of the present invention during the operation of correcting distortion of images;

FIG. **38** is a flowchart showing a sequence of processing steps executed by the image altering part and a display control part of the image processing apparatus according to the sixth embodiment of the present invention during the operation of correcting distortion of images;

FIG. **39** is an illustration showing a resulting image for which distortion correction has been performed in the image processing apparatus according to the sixth embodiment of the present invention during the operation of correcting distortion of images;

FIG. **40** is a flowchart showing processing steps executed by an image arranging part of the image processing apparatus according to the sixth embodiment of the present invention during the operation of correcting distortion of images;

FIG. **41** is a functional block diagram showing the arrangement of an image altering part and the surroundings

in an image processing apparatus according to the seventh embodiment of the present invention during the operation of correcting distortion of images;

FIG. 42 is an illustration showing an example of a display screen on a display part of the image processing apparatus according to the seventh embodiment of the present invention during the operation of correcting distortion of images;

FIG. 43 is a flowchart showing part of processing steps executed by the image altering part and a display control part of the image processing apparatus according to the seventh embodiment of the present invention during the operation of correcting distortion of images;

FIG. 44 is a functional block diagram showing the arrangement of an image altering part and the surroundings in an image processing apparatus according to the eighth embodiment of the present invention during the operation of correcting distortion of images;

FIG. 45 is a flowchart showing part of processing steps executed by the image altering part and a display control part of the image processing apparatus according to the eighth embodiment of the present invention during the operation of correcting distortion of images;

FIG. 46 is a functional block diagram showing the arrangement of an image altering part and the surroundings in an image processing apparatus according to the ninth embodiment of the present invention during the operation of correcting distortion of images;

FIG. 47 is an illustration showing an example of a display screen on a display part of the image processing apparatus according to the ninth embodiment of the present invention during the operation of correcting distortion of images; and

FIG. 48 is a flowchart showing part of processing steps executed by the image altering part and a display control part of the image processing apparatus according to the ninth embodiment of the present invention during the operation of correcting distortion of images.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to appended drawings, the present invention will be described in detail below with respect to preferred embodiments of an image processing apparatus, an image processing method and a computer-readable recording medium with a program recorded thereon for making the computer execute the method.

First, description is made to the general structure of an illustrated-document creating system including an image processing apparatus according to the present invention commonly used for joining and joining plural images together and correcting distortion of the images.

FIG. 1 is an illustration functionally showing the general structure of an illustrated document creating system including an image processing apparatus according to the present invention. As functionally shown in FIG. 1, the illustrated-document creating system is such that a host computer system 105 is connected by a network such as LAN to an image processing apparatus 100 including an input part 101, a processing part 102 and an output part 103.

The input part 101 performs read processing of images, which may include a scanner, an IC card, a digital still camera or a photo CD reader. The input part 101 reads or takes in images, and converts the read images into a predetermined file form before transmission to the processing part 102.

The processing part 102 performs read processing of images, such as to register, delete and alter the images. For example, a personal computer (PC) may be used for the processing part 102. An image data storage part 104, incorporated in the processing part 102 or externally connected to the processing part 102 stores processed image data, which may include an internal hard disk of the PC, a floppy disk, a rewritable CD-ROM, an MO or a DVD. The processing part 102 also retrieves image data stored in the image data storage part 104, pastes the retrieved image data on another document and controls a display to indicate the document or controls the output part 103 to print out the document.

The output part 103 performs the printing processing of image data and documents containing the image data to be printed out under control of the processing part 102. The output part 103 may include a monochrome or full-color laser printer or a digital copying machine. The output part 103 may also include a printer having such a function as to print business cards or laminate cards such as IC cards after printout of the cards.

The host computer system 105, connected by a network such as LAN to a PC as the processing part 102, includes a host computer 106 and plural terminals 107 connected by a network to the host computer 106. The host computer 106 may store therein, for example, a personnel information file 108 related to personnel affairs inside the company so that each terminal 107 can access to the personnel information file 108.

The processing part 102 can be linked with the personnel information file 108. For example, image data stored in the image data storage part 104 of the processing part 102 can be retrieved via the personnel information file 108 by inputting personnel information such as an employee number from a terminal 107.

Specifically, the illustrated-document creating system can be applied to a business card creating system for creating business cards with a photograph of one's face; a postcard creating system for creating postcards such as invitation cards with illustrated products or photographs of staff's faces thereon; an ID card creating system for creating an identity card (ID card) with a photograph; a leaflet creating system for creating leaflets such as a project document, a handbill and a catalog; a card creating system for creating illustrated cards; a personnel information system for creating and administering a personnel master file with photographs of personnel's faces such as personnel's photographs, their resumes or self-declarations, a name and address book and maps; a used-car search system for searching information with photographs of used cars; a stock information planning and purchasing system for controlling stock information; a system for the civil engineering and construction business, which is made up of a combination of a work schedule and a construction master file; and construction perspective creating system for use in combination with a three-dimensional CAD system. These illustrated-document creation systems may use or create color images such as color photographs.

The hardware configuration of the image processing apparatus 100 is described below. FIG. 2 is a block diagram showing the hardware configuration of the image processing apparatus 100. Shown in FIG. 2 are a CPU 201 for controlling the entire system, a ROM 202 with a boot program and the like stored therein, a RAM 203 used as a work area of the CPU 201, an HDD (hard disk drive) 204 for performing reading/writing of data with respect to an HD (hard disk) 205 under control of the CPU 201, an HD 205 for storing data written under control of the HDD 204, an FDD (floppy disk drive) 206 for performing reading/writing of data with

respect to an FD (floppy disk) 207 under control of the CPU 201. a removable FD 207 for storing data written under control of the FDD 206, and a display 208 for displaying documents containing images, function information and the like.

An interface (I/F) 209, connected to a network NET through a communication channel 210 controls an internal interface with the network NET; a keyboard 211 provided with keys for input of characters, numerical values and various instructions; a mouse 212 for moving a cursor and designating a selected area and the like; a digital still camera 213 for photographing images with a CCD; a printer 214 for printing out documents; and a bus 215 for connecting the above components. The digital still camera 213 may be replaced by a scanner for optically reading images.

FIG. 3 is a functional block diagram showing the structure of the image processing apparatus 100. In FIG. 3, the processing part 102 includes, in addition to the image data storage part 104, an operation guidance part 301, an image registration part 302, an image deleting part 303, an image altering part 304, an image retrieving part 305, an image joining part 306, a display control part 307, a display part 308, a printing control part 309 and the like.

The operation guidance part 301 instructs the image registration part 302, the image deleting part 303, the image altering part 304, the image retrieving part 305, the image joining part 306, the display control part 307 and the printing control part 309 to operate according to the contents of the display part 308. For example, the operation guidance part 301 includes pointing devices such as the keyboard 211 and the mouse 212.

The image registration part 302 receives image data transmitted from the input part 101 to register the image data as an image data file by adding predetermined data such as a file name. The image data file so registered is stored into the image data storage part 104. The image deleting part 303 deletes any of the image data already stored in the image data storage part 104 from the image data storage part 104 in accordance with a deleting instruction from the operation guidance part 301.

The image altering part 304 adds a change in image data of any image data file, already stored in the image data storage part 104 in accordance with an altering instruction from the operation guidance part 303, and restores the altered image data into the image data storage part 104. The image altering part 304 will be described in detail later.

The image retrieving part 305 retrieves a desired image data file from the image data files already stored in the image data storage part 104 in accordance with a retrieving instruction from the operation guidance part 301. The image joining part 306 selects image data already stored in the image data storage part 104 so that the selected image data will be pasted on a document in accordance with an instruction from the operation guidance part 301.

The display control part 307 controls the display part 308 to indicate on its display screen an image of an image data file stored in the image data storage part 104, or a reduced image or thumbnail of the image, in accordance with a display instruction from the operation guidance part 301. The display control part 307 will be described in detail later.

The printing control part 309 transmits to the output part 103 printing data such as image data or an illustrated document in accordance with a printing instruction from the operation guidance 301. The output part is also controlled in accordance with operating instructions from the operation guidance 301 such as to set the number of prints and the like.

The image registration part 302, the image deleting part 303, the image altering part 304, the image retrieving part 305, the image joining part 306, the display control part 307 and the printing control part 309 are embodied, respectively, by the CPU 201 or the like executing command processing according to commands written in programs such as an OS and an application program recorded on recording media such as the ROM 202, the RAM 203, the hard disk 205 or the floppy disk 207.

The display part 308 displays documents containing images, character strings and the like under control of the display control part 307. The display part 308 may be the display 208 including a CRT or liquid crystal display.

The present invention will be described first with regard to image editing according to an embodiment, where plural picture images are joined together to form a picture.

First Embodiment

In the embodiment in which plural picture images are edited into a picture, the arrangements of the image altering part 304 and the display control part 307 are first described in more detail. FIG. 4 is a functional block diagram showing the arrangement of the image altering part 304, the display control part 307 and the surroundings in the image processing apparatus according to the first embodiment. As shown in FIG. 4, the image altering part 304 includes an image specifying part 401, an image arranging part 402, a joining point specifying part 403 and a joining part 404.

The image specifying part 401 is for specifying two or more images to be joined together. The image specifying part 401 specifies images the operator wants to join in accordance with an operating instruction from the operation guidance part 301.

The image arranging part 402 arranges the images specified by the image specifying part 401 in such a layout as to join them in that order. The images may be arranged in a line or lines, vertically or laterally. The images specified by the image specifying part 401 are thus arranged or rearranged in accordance with the operating instruction from the operation guidance part 301 in such a layout as to join the images in that order.

The joining point specifying part 403 specifies a joining point for each image so that vertically or laterally adjacent images displayed on the display screen of the display part 308 under control of the display control part 307 can be joined by referring to the joining point.

The processing contents of the image specifying part 401, the image arranging part 402 and the joining point specifying part 403 will be described in detail later.

The joining part 404 joins the adjacent images by referring to the joining point specified by the joining point specifying part 403. Such images can be joined together, for example, by a method such as one disclosed in Japanese patent application No. 9-316679 or 10-91125 of the same applicant. The image produced by the images joined together by the joining part 404 is then assigned a file name. and stored in the image data storage part 104 based on the file name.

The image specifying part 401, the image arranging part 402, the joining point specifying part 403 and the joining part 404 are embodied, respectively, by the CPU 201 or the like executing command processing according to commands written in programs such as an OS and an application program recorded on recording media such as the ROM 202, the RAM 203, the hard disk 205 or the floppy disk 207.

The display control part 307 controls the display part 308 to display a joining window 700 and to display images arranged by the image arranging part 402 in a joining work area 701 of the joining window 700, as shown in FIG. 7.

Next, the operations of the image processing apparatus and the contents of display screens are described with respect to concrete display examples. FIG. 5 is an illustration showing an example of a display screen appearing on the display part 308 of the image processing apparatus according to the first embodiment. Shown in FIG. 5 is the basic display screen of the image processing apparatus according to the first embodiment. In FIG. 5, the display screen is made up of three areas: a file name display area 501 occupying almost the upper half of the left side of the screen, a reduced image display area 502 occupying the lower side of the file name display area 501, and a selected image display area 503 occupying almost the right half of the screen.

Preferably, these areas are not displayed in a multi-window form, but are configured as fixed areas for the purpose of inhibiting the operator from changing the position and size of these areas. Since the screen is displayed in the same layout at any time, the operator can grasp these areas as one screen. This makes it possible for the operator to use the image processing apparatus intuitively without confusion during the operation and without the need to memorize complicated operating procedures, and hence may edit and process images efficiently.

File names stored in the image data storage part 104 such as the hard disk 205 or the floppy disk 207 are displayed in the hierarchical order in the file name display area 501. The operator can thus select a desired data file by retrieving and specifying the name of the desired data file while viewing the file names displayed in the file name display area 501.

Plural reduced images or thumbnails are created by a reduced image creating part scaling down actual image data at a predetermined magnification rate, and are displayed in the reduced image display area 502. This makes it possible for the operator to view the reduced images so as to recognize instantaneously which file the image data corresponds to. Each file name is also displayed under each reduced image.

A desired image can also be selected by moving the cursor onto the corresponding reduced image and clicking the button of the mouse 212 or the like, instead of specifying the file name in the file name display area 501. In this case, the operator can use the reduced image as a clue to the desired image data file to achieve easy, high-speed selection of the desired image even if the operator has only a vague memory of the file name.

If a predetermined key word is registered for each image data file, such as "character" or "landscape," "business" or "private", the reduced images can be displayed by arranging the display sequence of the reduced images based on the key words. Since the reduced images are arranged based on the key words, a desired image data file can be retrieved at high speed even if the number of registered image data files is large.

In the display example of FIG. 5, eight reduced images are displayed in each of three rows, i.e., the number of reduced images displayed is set to 24, but the arrangement and number of reduced images displayed can be varied according to the resolution of the display and the contents of displayed images, or the difference in retrieving method.

The selected image display area 503 is an area for displaying an image of the image data file selected by specifying the file name in the file name display area 501, or by specifying the corresponding thumbnail in the reduced image display area 502. The selected images may be displayed in the following modes: a standard display mode for displaying the selected image of a standard size, a full-screen display mode for scaling up or down the display frame of the selected image to display the entire frame of the selected image, and a variable magnification display mode for displaying the selected image enlarged or reduced to predetermined magnification desired by the operator. The variable magnification display mode is specified by inputting the percentage of magnification. When the percentage is set to 100%, the magnification becomes equal to the size of the selected image. When a value smaller than 100% is input, the selected image is reduced, and when a value larger than 100% is input, the image is enlarged.

By specifying a predetermined command from the menu, or double-clicking the image itself, the image currently displayed in tile selected image display area 503 can be fully displayed on the display screen while concealing the file name display area 501 and the reduced image display area 502 behind the selected image display area 503. This makes it possible to edit and process the selected image more efficiently. This full-screen display of the selected image is particularly effective in processing a large image. After completion of editing and processing operations, the full-screen display of the selected image can be resized and returned to the home image area by specifying a predetermined command from the menu, or double-clicking the image itself again. The file name display area 501 and the reduced image display area 502 are then redisplayed.

Next, description is made to the operating procedures for specifying images executed by the image specifying part 401. FIG. 6 is an illustration showing another example of the display screen on the display part 308 of the image processing apparatus according to the first embodiment. In FIG. 6, the number of reduced images displayed in the reduced image display area 502 is set to eight for convenience sake.

Referring to FIG. 6, plural images to be joined together are specified from the reduced images in the reduced image display area 502. Although such plural images can be specified by using the keyboard to input the file names of corresponding reduced images, the plural images are specified here by using a pointing device such as the mouse 212 or the like to move the cursor to the reduced image display area and click the button of the mouse 212 or the like.

Since the plural reduced images need to be specified in one specifying operation, the button of the mouse 212 is clicked while pressing a specific key such as the shift key on the keyboard 211, thus easily specifying plural reduced images.

FIG. 6 shows a case where three reduced images 601, 602 and 603 are specified as images to be joined together. These reduced images specified may be made distinguishable from the others by displaying the file names of the reduced images specified as a negative, or enclosing the reduced images with a bold frame, so that the operator can recognize the reduced images specified.

After specifying the reduced images, the operator moves the cursor to an "IMAGE CORRECTION" menu 604 on the menu bar in FIG. 6, clicks the button of the mouse 212 or the like, and further clicks an "IMAGE JOINING" menu 605 displayed as one of pull-down menus to select the image joining function. Then, the joining window 700 is popped up and displayed as shown in FIG. 7.

Next, the processing contents of the image arranging) part 402 are described. FIGS. 7 to 9 are illustrations showing

other examples of display screens on the display part 308 of the image processing apparatus according to the first embodiment. The joining window 700 includes a joining work area 701, a mode switching part 702, an arrangement switching part 703, a scale-up button 704, a scale-down button 705, a start button 706, and a cancel button 707.

Images specified by the image specifying part 401 are displayed in the joining work area 701. In FIG. 7, the reduced images 601, 602 and 603 specified in FIG. 6 are enlarged to predetermined magnification and displayed (corresponding to the images 751, 752 and 753, respectively).

The mode switching part 702 has two click modes for the pointing device such as the mouse 212 or the like: an image position replacing mode 708 and a joining position specifying mode 709.

Icons are arranged on the arrangement switching part 703 for switching the arrangement or layout in which the images specified by the image specifying part 401 are displayed. If three images are to be specified, since the three images will be arranged vertically or laterally, the two types of arrangements are shown as icons. As shown in FIG. 8, an icon 710 indicates a lateral arrangement of three images and an icon 711 indicates a vertical arrangement of three images. The operator can move the cursor onto either of the icons and click the button of the mouse 212 or the like to switch the arrangement of the images displayed on the work area 701. The icons displayed on the arrangement switching part 703 vary in shape and number according to the number of images specified by the image specifying part 401.

FIG. 7 shows a case where the icon 711 shown in FIG. 8 has been selected. The three images 751, 752 and 753 are displayed on the work area 701 in the same arrangement as the icon 711, i.e., by aligning these images in the vertical direction. On the other hand, FIG. 8 shows a case where the icon 710 has been selected. Thus, the arrangement of images can be changed by such a simple operation as to select the icon.

The scale-up button 704 is to scale up the size of images displayed on the joining work area 701. The images are scaled up to predetermined magnification each time the scale-up button 704 is pressed. i.e., when the operator moves the cursor onto the scale-up button 704 and clicks the button of the mouse 212 or the like one time. The scaled-up images are thus displayed on the joining work area 701, and this makes it easy for the operator to specify joining points.

FIG. 9 is an illustration showing yet another example of the display screen on the display part 308 of the image processing apparatus according to the first embodiment. FIG. 9 shows a case where the scale-up button 704 has been pressed once.

The scale-down button 705 is used to scale down the images, in a way opposite to the scale-up button 704, to predetermined magnification identical to that of the scale-up button 704, according to the number of times the button is pressed. If the scale-down button 705 is pressed as many times as the scale-up button 704 is pressed, the images will be returned to the original size. Since the size of images can not be scaled down any more in FIG. 7, the scale-down button 705 is grayed out, and pressing the button 705 is now inhibited.

The start button 706 instructs the start of joining processing of the images. Since no joining points have been specified yet, the start button 706 is grayed out, and pressing the start button 706 is inhibited.

The cancel button 707 instructs cancellation of the joining processing. If the cancel button 707 is pressed, the joining processing currently being performed is stopped, and the joining window 700 is closed.

Further, since joining points need to be specified by the joining point specifying part 403 for each pair of the adjacent images displayed on the joining work area 701, the images must be displayed in such a layout as to join the images in that order. For this reason, the image arranging part 402 performs position replacement processing of the images.

FIGS. 10*a*–10*c* are illustrations for explaining the image position replacement executed by the image arranging part 402 of the image processing apparatus according to the first embodiment. At first, the click mode on the mode switching part 702 shown in FIG. 7 is switched to the image position replacing mode 708. Then, an image to be replaced with another is specified. The image specification may be done by clicking a desired image, for example, an image A in FIG. 10*a*, with the mouse 212 or the like.

The desired image A is dragged to, and dropped in the neighborhood of another image B displayed in a position in which the operator wants to replace the image A with the image B, as shown in FIG. 10*b*. As a result, the desired image A is moved to the position in which the image B has been located, while the image B is moved to the original position of the desired image A, as shown in FIG. 10c.

If the click mode on the mode switching part 702 is in the image position replacing mode 708, the same operation can be performed repeatedly. This makes it possible for the operator to perform image replacement efficiently at high speed.

Next, the processing contents of the joining point specifying part 403 are described. At first, the click mode on the mode switching part 702 is switched to the joining position specifying mode 709. FIG. 11 is an illustration showing yet another example of the display screen on the display part of the image processing apparatus according to the first embodiment.

In FIG. 11 (or 9), adjacent images in the joining work area 701 are compared by the user to specify, with the pointing device such as the mouse 212, respective characteristic points at which an identical image character appears on both images. To specify the characteristic points accurately, the images should be enlarged to a certain extent, for example, as shown in FIG. 11.

Specifically, in this example, the tips of lampposts 1102 and 1103, located on the center left of the overlapped parts of both images 752 and 753, are suitable for joining points. The joining points are specified by moving the cursor to these tips 1102 and 1103 and clicking the button of the mouse 212 or the like. Coordinate data indicative of the joining points specified are then stored in a storage area provided in the joining point specifying part 403. Such joining points are specified for each pair of vertically or laterally adjacent images.

After completion of specifying the joining points for all the adjacent images, the operator presses the start button 706 to start execution of the joining processing. When the joining processing is completed, an image resulting from the joining processing is displayed in the joining work area 701, and a window 1200 is displayed with a message: Is this result OK?

FIG. 12 is an illustration for explaining an example of such a window displayed on the display part of the image processing apparatus according to the first embodiment. In FIG. 12, if an "yes" button 1201 is pressed, the image resulting from the joining processing is assigned a file name

and stored into the image data storage part **104**. On the other hand, if a "no" button **1202** is pressed, the joining result is canceled and the operating procedure returns to the display screen just before the start button **706** is pressed, so that joining points can be specified again.

Next, description is made to a sequence of processing steps executed by the image altering part **304** and the display control part **307** according to the first embodiment. FIG. **13** is a flowchart showing a sequence of processing steps executed by the image altering part and the display control part according to the first embodiment. In the flowchart of FIG. **13**, it is first determined whether two or more images are specified or not (step **S1301**). The operation remains instep **S1301** until two or more images are specified (until step **S1301** becomes affirmative), and it is then determined whether joining is instructed or not (step **S1302**).

If joining is not instructed in step **S1302** (step **S1302** is negative), it is determined whether other instructions such as deletion of images are given or not (step **S1303**). If no other instruction is given here (step **S1303** is negative), the procedure returns to step **S1301**, and the subsequent processing steps are repeated. If any other instruction is given in step **S1303** (step **S1303** is affirmative), this operation is ended after execution of the corresponding processing (step **S1304**).

If joining is instructed in step **S1302** (step **S1302** is affirmative), arrangement processing is executed for the specified images (step **S1310**). The image arrangement procedures will be described in detail later.

It is next determined whether the image arrangement is to be altered or not (step **S1340**). If alteration is required (step **S1340** is affinnative), the procedure returns to step **S1310** in which the images are rearranged. If alteration is not required in step **S1340** (step **S1340** is negative), it is determined whether joining points are specified or not (step **S1350**). If any joining points are specified (step **S1350** is affirmative), coordinate data of the joining points specified are saved (step **S1365**). The processing steps **S1350** through **S1370** are repeated until all the joining points are specified. When all the joining points have been specified (step **S1370** is affirmative), it is further determined whether to alter any of the joining points (step **S1380**).

If alteration of any joining points is required in step **S1380** (step **S1380** is affirmative), the procedure returns to step **S1350**. On the other hand, if alteration of any joining points is not required in step **S1380** (step **S1380** is negative), it is determined whether the start button is pressed or not (step **S1381**). If the start button is pressed (step **S1381** is affirmative), joining processing is executed, using the conventional technique disclosed in Japanese patent application No. 9-316679 or **10**-91125 (which are hereby incorporated by reference) (step **S1382**) to display the joined image on the display screen of the display part **308** (step **S1383**).

It is next determined whether the displayed result is OK or not (step **S1384**). If the result is not OK (step **S1384** is negative), the procedure returns to step **S1350** to specify joining points again. On the other hand, if OK in step **S1384**, the result is stored (step **S1385**), and all the processing is ended.

If the start button is not pressed in step **S1381** (step **S1381** is negative), it is determined whether alteration in image arrangement is required or not (step **S1390**). If alteration is required (step **S1390** is affirmative), the procedure returns to step **S1310** and the subsequent processing steps are repeated. On the other hand, if alteration is not required (step **S1390** is negative), the should be altered or not. After that, the subsequent processing steps are repeated.

Next, the image arrangement processing executed at step **S1310** is described in detail. FIG. **14** is a flowchart showing processing steps executed by the image arranging part **402** according to the first embodiment. If joining is instructed in step **S1302** of the flowchart of FIG. **13** (step **S1302** is affirmative), determination is made in the flowchart of FIG. **14** as to whether alteration in image arrangement is instructed or not (step **S1311**). If instructed (step **S1311** is affirmative), the alteration in image arrangement is performed (step **S1312**). On the other hand, if not instructed (step **S1311** is negative), the procedure goes to the next step without execution of any processing.

It is next determined whether image replacement is instructed or not (step **S1313**). If instructed (step **S1313** is affirmative), the image replacement is performed (step **S1314**). On the other hand, if not instructed (step **S1313** is negative), the procedure goes to the next step without execution of any processing.

It is next determined whether an enlargement of the images is possible or not (step **S1315**). If possible (step **S1315** is affirmative), determination is made as to whether the enlargement is instructed or not (step **S1316**). If instructed (step **S1316** is affirmative), the enlargement is performed (step **S1317**). On the other hand, if it is not possible to enlarge the images (step **S1315** is negative), or if the enlargement is not instructed (step **S1316** is negative), the procedure goes to the next step without execution of any processing.

It is next determined whether a reduction of the images is possible or not (step **S1318**). If possible (step **S1318** is affirmative), determination is made as to whether the reduction is instructed or not (step **S1319**). If instructed (step **S1319** is affirmative), the reduction is performed (step **S1320**). On the other hand, if it is not possible to reduce the images (step **S1318** is negative), or if the reduction is not instructed (step **S1319** is negative), the procedure goes to the next step, i.e., step **1340**, without execution of any processing.

As discussed above, when plural images are joined together, the first embodiment makes it easy to specify and arrange the images, and to specify joining points for adjacent images.

Second Embodiment

Although in the first embodiment one joining point is specified at a point, i.e., by clicking the button of the mouse **212** or the like, it may be specified using a line, i.e., by specifying the joint between adjacent images in a drag-and drop operation of the mouse **212** or the like, as discussed in the following second embodiment.

Since the general structure of the illustrated document creating system including an image processing apparatus according to the second embodiment of the present invention, and the hardware configuration of the image processing apparatus **100** are substantially the same as those of the first embodiment, description thereof is omitted here. Further, since the image processing apparatus **100** includes substantially the same parts as those of the first embodiment except the image altering part **304** and the display control part **307**, the parts common to those of the first embodiment are also not described here.

Next, the image altering part **304** is described. FIG. **15** is a functional block diagram showing the arrangement of the image altering part **304** and the surroundings in the image processing apparatus according to the second embodiment of the present invention. As shown in FIG. **15**, the image

altering part **304** includes an image specifying part **1501**, an image arranging part **1502**, a joining point specifying part **1503**, a joining part **1504** and a connection line drawing part **1505**. Since parts other than the joining point specifying part **1503** and the connection line drawing part **1505** are substantially the same as those of the first embodiment description thereof is omitted.

The joining point specifying part **1503** has substantially the same structure as that of the joining point specifying part **403** of the first embodiment, in which any one joining point is specified for each image so that vertically or laterally adjacent images, displayed on the display screen of the display part **308** under control of the display control part **307**, can be joined by referring to the joining point, but differs from the joining point specifying part **403** in method of specifying the joining point. The connection line drawing part **1505** is to draw a connection line between the joining points specified by the joining point specifying part **1503**. The processing contents of the joining point specifying part **1503** and the connection line drawing part **1505** will be described in detail later.

The image specifying part **1501**, the image arranging part **1502**, the joining point specifying part **1503**, the joining part **1504** and the connection line drawing part **1505** are embodied, respectively, by the CPU **201** or the like executing command processing according to commands written in programs such as an OS and an application program recorded on recording media such as the ROM **202**, the RAM **203**, the hard disk **205** or the floppy disk **207**.

The display control part **307** controls the display part **308** to display not only images arranged by the image arranging part **1502**, but also a connection line **1621** drawn by the connection line drawing part **1505** as shown in FIG. **16**.

Next, description is made to specification processing of joining points and drawing processing of a connection line executed by the joining point specifying part **1503** and the connection line drawing part **1505**. FIG. **16** is an illustration showing an example of a display screen on the display part **308** of the image processing apparatus according to the second embodiment. In FIG. **16**, the operator switches the click mode to the joining position specifying mode, compares adjacent images **1602** and **1603** to specify characteristic points at which an identical image character appears on both images. The operator then moves the cursor to one point **1612** on the image **1602**, clicks (presses) the button of the mouse **212** or the like, and moves (drags) the cursor to the other point **1613** on the image **1603** by moving the mouse **212** while maintaining a pressed state of the button. The connection line drawing part **1505** is synchronized with the movement of the cursor to draw the connection line **1621** on the coordinates identical to the cursor path on the screen. When the cursor reaches the point **1613**, the operator releases (drops) the pressed state of the button. The connection line **1621** drawn by the connection line drawing part **1505** is thus fixed.

The joining points are specified as such above. Coordinate data of the joining points specified are saved (stored) in a storage provided inside the joining point specifying part **1503**. As in the first embodiment, the specification processing of joining points is performed for each pair of vertically or laterally adjacent images. After completion of the specification processing for all the adjacent images, the operator can press the start button to start execution of joining processing.

Thus, the joining points can be specified by the simplest way by pressing the button of the mouse or the like, moving the mouse while pressing the button, and releasing the pressed button in a predetermined position.

The connection line **1621** may be such a colored line that it can be easily discriminated, such as a red line. The connection line may also have such a thickness that is can be easily discriminated. The line types, such as color and thickness, may be selectable by the operator, or selectable automatically depending on the image by taking into account a color used in the image so that the connection line can be more easily discriminated from the color.

The connection line **1621** may be displayed as a dotted line during drag operation, and changed to a solid line after drop operation to fix the connection line. This makes it possible for the operator to easily confirm the process of specifying the connection line.

Next, description is made to a sequence of processing steps executed by the image altering part **304** and the display control part **307** according to the second embodiment. FIG. **17** is a flowchart showing part of processing steps executed by the image altering part **304** and the display control part **307** according to the second embodiment. Since the flowchart of FIG. **17** executes the same processing steps as those from **S1301** to **S1340** and those from **S1365** to **S1390** in the flowchart of FIG. **13** according to the first embodiment, the common steps and their description are omitted.

In step **S1340** of the flowchart of FIG. **13** according to the first embodiment, if alteration in image arrangement is not required (step **S1340** is negative), determination is made in the flowchart of FIG. **17** as to whether the button of the mouse **212** or the like is pressed or not (step **S1351**). If the button is pressed (step **S1351** is affirmative), it is determined whether the cursor is positioned on an image or not (step **S1352**). If the cursor is not positioned on any image (step **S1352** is negative), an error indication is given (step **S1353**) and the procedure returns to step **S1351**. On the other hand, if the cursor is positioned on an image (step **S1353** is affirmative), drawing of a connection line is started at the point (step **S1354**).

After that, the operation remains in step **S1355** until the button of the mouse **212** or the like is released. When the button is released (step **S1355** becomes affirmative), it is determined whether or not the cursor is positioned on an image adjacent to the image on which the cursor has been located in step **S1352** (step **S1356**). If the cursor is not positioned on the adjacent image (step **S1356** is negative), an error indication is given (step **S1353**), and the procedure returns to step **S1351** to repeat the subsequent processing steps.

If it is determined in step **S1356** that the cursor is positioned on the adjacent image (step **S1356** is affirmative), the drawing of the connection line is ended (step **S1361**). After that, the procedure goes to step **S1365** of FIG. **13** according to the first embodiment.

As discussed above, according to the second embodiment, a connection line is drawn between joining points specified, so that the operator can not only specify the joining points as if he or she drew a line by hand, but also recognize instantaneously whether the joining points are specified or not.

Third Embodiment

The set of joining points already specified may be released when a new set of joining points is specified for a pair of adjacent images, as described in the following third embodiment. Since the general structure of the illustrated document creating system including an image processing

apparatus according to the third embodiment of the present invention, and the hardware configuration of the image processing apparatus **100** are the same as those of the first embodiment, description thereof is omitted here. Further, since the image processing apparatus **100** includes the same parts as those of the first embodiment except the image altering part **304**, the parts common to those of the first embodiment are also not described here.

Next, the image altering part **304** is described. FIG. **18** is a functional block diagram showing the arrangement of the image altering part **304** and the surroundings in the image processing apparatus according to the third embodiment of the present invention. As shown in FIG. **18**, the image altering part **304** includes an image specifying part **1801**, an image arranging part **1802**, a joining point specifying part **1803**, a joining part **1804**, a connection line drawing part **1805** and a joining-point specification releasing part **1806**.

Since parts other than the joining point specifying part **1803**, the connection line drawing part **1805** and the joining-point specification releasing part **1806** are the same as those of the first embodiment, and the connection line drawing part **1805** is the same as that of the second embodiment, description thereof is omitted.

The joining point specifying part **1803** may be either the joining point specifying part **403** of the first embodiment, or the joining point specifying part **1503**. The joining-point specification releasing part **1806** releases specification of the previous set of joining points when a set of joining points is specified for a pair of adjacent images for which another set of joining points has already been specified. The processing contents of the joining-point specification releasing part **1806** will be described in detail later.

The image specifying part **1801**, the image arranging part **1802**, the joining point specifying part **1803**. the joining part **1804**. the connection line drawing part **1805** and the joining point specification releasing part **1806** are embodied, respectively, by the CPU **201** or the like executing command processing according to commands written in programs such as an OS and an application program recorded on recording media such as the ROM **202**, the RAM **203**, the hard disk **205** or the floppy disk **207**.

Next, description is made to releasing processing of a set of joining points executed by the joining-point specification releasing part **1806**. When a set of joining points is specified for a pair of adjacent images, the joining-point specification releasing part **1806** recognizes whether another set of joining points has already been specified for the adjacent images, by referring to whether or not coordinate data of the corresponding joining points are stored in a storage area provided inside the joining point specifying part **1803**.

Further, when a new set of joining points is specified, the joining-point specification releasing part **1806** releases the previous joining points by deleting corresponding coordinate data stored, and stores the set of joining points newly specified. Thus, the joining points can be easily changed. The joining-point specification releasing part **1806** also deletes a connection line, if any, drawn between the joining points already specified.

Next, description is made to a sequence of processing steps executed by the image altering part **304** and the display control part **307** according to the third embodiment. FIG. **19** is a flowchart showing parts of processing steps executed by the image altering part **304** and the display control part **307** according to the third embodiment.

Since the flowchart of FIG. **19** executes the same processing steps as those from **S1301** to **S1340** and those from **S1365** to **S1390** in the flowchart of FIG. **13** according to the first embodiment, the common steps and their description are omitted. Further, the flowchart of FIG. **19** also executes the same processing steps as those from **S1351** to **S1356** and **S1365**; description thereof is omitted as well.

In step **S1356**, if the cursor is positioned on the adjacent image (step **S1356** is affirmative), it is then determined whether joining points are specified for the adjacent images or not (step **S1357**). If the joining points are not specified (step **S1357** is negative), the procedure shifts to step **S1361** without execution of any processing.

On the other hand, if the joining points are specified (step **S1357** is affirmative), the joining points arc released (step **S1358**). The connection line drawn between the joining points is then deleted (step **S1359**), and the procedure goes to step **S1361**.

As discussed above, according to the third embodiment, when a set of joining points is specified for adjacent images for which another set of joining points has already been specified, the joining-point specification releasing part **1806** releases the previous set of joining points already specified, so that when specifying a new set of joining points, the operator can change the specification of joining points easily and efficiently in the same operation when specifying a set of joining points for the first time without the need to release the specification of the previous set of joining points.

Fourth Embodiment

Although the above first to third embodiments have been made for images photographed with a digital still camera **213** having a fixed focal length, i.e., these embodiments assume that the focal length is invariable, the focal length may be set for proper joining of images even if the images have been photographed with a digital still camera **213** having variable focal lengths, as discussed in the following fourth embodiment.

When two or more images for joining together are photographed at different focal lengths, because these images differ in image size depending on the focal length, it is difficult to join these images together. The fourth embodiment has been made to solve the problem by standardizing the focal length of the images so that the images can be joined together. Since the general structure of the illustrated document creating system including an image processing apparatus according to the fourth embodiment of the present invention, and the hardware configuration of the image processing apparatus **100** are the same as those of the first embodiment, description thereof is omitted here. Further, since the image processing apparatus **100** includes the same parts as those of the first embodiment except the image altering part **304**, the parts common to those of the first embodiment are also not described here.

Next, the image altering part **304** is described. FIG. **20** is a functional block diagram showing the arrangement of the image altering part **304** and the surroundings in the image processing apparatus according to the fourth embodiment of the present invention. As shown in FIG. **20**, the image altering part **304** includes an image specifying part **2001**, an image arranging part **2002**, adjoining point specifying part **2003**, a joining part **2004**, a connection line drawing part **2005**, a joining-point specification releasing part **2006**, a focal length setting part **2007** and an image correcting part **2008**. The parts other than the focal length setting part **2007** and the image correcting part **2008** are the same as those of the first to third embodiments, and therefore description thereof is omitted.

The focal length setting part **2007** sets the focal length of an image, photographed with a digital still camera **213** or the like in accordance with an operating instruction from the operation guidance part **301**. The focal length may be set by directly inputting a numerical value for the focal length, or otherwise, from a table related to camera types and their focal lengths pre-stored in the table. The processing contents of the focal length setting part **2007** will be described in detail later.

The image correcting part **2008** corrects the image to be joined with other images based on data of the focal length set by the focal length setting part **2007**. The correction processing may include correction of distortion of an image resulting from distortion aberration of the optical system of the image. Specifically, a distortion aberration coefficient is estimated based on the focal length data to execute the distortion correction for each image using the estimated distortion aberration coefficient. The distortion may be corrected, for example, by a method such as one disclosed in Japanese application No. 9-303893 (U.S. patent application Ser. No. 08/807,571, filed Feb. 27, 1997) of the same applicant.

The image specifying part **2001**, the image arranging part **2002**, the joining point specifying part **2003**, the joining part **2004**, the connection line drawing part **2005**, the joining-point specification releasing part **2006**, the focal length setting part **2007** and the image correcting part **2008** are embodied, respectively, by the CPU **201** or the like executing command processing according to commands written in programs such as an OS and an application program recorded on recording media such as the ROM **202**, the RAM **203**, the hard disk **205** or the floppy disk **207**.

Next, description is made to focal-length setting processing executed by the focal length setting part **2007**. FIG. **21** is an illustration showing an example of a display screen on the display part **308** of the image processing apparatus according to the fourth embodiment. There is shown in FIG. **21** a focal length button **2101** to open a focal length setting window **2102** for setting the focal length. In FIG. 21, since the focal length setting button **2101** has already been pressed, the focal length setting window **2102** is in the popped-up state.

The focal length setting window **2102** includes an input frame **2103** into which the type of digital still camera **213** is input, a zoom switching part **2104**, an OK button **2105** and a cancel button **2106**.

The name of a digital still camera can be directly input into the input frame **2103**, but in general, the rightmost button is pressed to display a list of the names of digital still cameras so that the name of a digital still camera with which an image to be joined has been photographed can be selectively input. The standard focal lengths of the listed cameras is stored.

The zoom switching part **2104** is to switch the mode related to the zoom depending on whether the image to be joined has been photographed in the zoom mode or not. When no zoom is used for the photograph. the mode is switched to "standard," i.e., the standard focal length for the specified camera. On the other hand, when the zoom is used for the photograph, the mode is switched to "maximum," i.e., maximum zoom for the camera specified.

Although in the embodiment switching is enabled between two kinds of modes, more than two zoom modes can be used for switching over among them depending on the types of digital still cameras and the kinds of zooms. In some types of digital still cameras, the information related to setting of the focal length may be added to the image data. In this case, the focal length may be automatically set by reading the information related to setting of the focal length.

After completion of input of the name of a digital still camera and switching of the zoom mode. the operator may press the OK button **2105** to end the setting processing of the focal length and close the focal length setting window **2102**. or the cancel button **2106** to cancel the setting process and close the focal length setting window **2102**.

Next, description is made to a sequence of processing steps executed by the image altering part **304** and the display control part **307** according to the fourth embodiment. FIG. **22** is a flowchart showing part of processing steps executed by the image altering part and the display control part according to the fourth embodiment.

Since the flowchart of FIG. **22** executes the same processing steps as those from **S1301** to **S1310** and those from **S1340** to **S1390** in the flowchart of FIG. **13** according to the first embodiment, the marks of the common steps and their description are omitted. The flowchart of FIG. **22** also executes the same processing steps as those from **S1311** to **S1320** in the flowchart of FIG. **14** according to the first embodiment and therefore description thereof is omitted as well.

In the flowchart of FIG. **22**, if step **S1319** is negative or step **S1320** is affirmative, determination is made as to whether focal-length setting processing is instructed or not (step **S1331**). If instructed (step **513311** is affirmative), the focal-length setting processing is performed (step **S1332**). On the other hand, if not instructed (step **S1331** is negative), the procedure goes to the next step, i.e., step **S1340**, without execution of any processing.

As discussed above, according to the fourth embodiment, the focal length setting part **2207** sets the focal length with which an image has been input, while the image correcting part **2208** corrects the image based on the focal length set, for joining the image with another. This makes it possible to join images together without occurrence of distortion even if the images have been input by input devices with different focal lengths.

Fifth Embodiment

Since the above first to fourth embodiments assume a case where a maximum of three images can be arranged both in the vertical direction and in the lateral direction, such a number of images (two, three, four, six or nine) as to shape the joined image into a square or rectangle can only be joined together. However, the number of images to be arranged vertically or laterally can be so increased that further different combinations of images (such as eight images, arranged two in length and four in width, or four in length and two in width) can be arranged. This embodiment is discussed below on the assumption that such a number of images as to make the joined image into a rectangular shape can be set, but the present invention is not limited by these cases, and such combinations of images as to form unique shapes other than rectangles may be set. Further, plural images such as four images, five images, six images, seven images, eight images, nine images and so on may be so joined that a panorama of landscape type can be formed.

Since the general structure of the illustrated document creating system including an image processing apparatus according to the fifth embodiment of the present invention, and the hardware configuration of the image processing apparatus **100** are the same as those of the first embodiment, description thereof is omitted here. Further, the functional

configuration of the image processing apparatus **100** is the same as that of the first to fourth embodiments and therefore description thereof is omitted as well.

FIG. **23** is an illustration showing an example of a display screen on the display part **308** of the image processing apparatus according to the fifth embodiment. A joining window **2300** includes a joining work area **2301**, a mode switching part **2302**, an arrangement switching part **2303**, a zoom switching part **2304**, a camera switching part **2305**, a scale-up button **2306**, a scale-down button **2307**, a start button **2308** and a cancel button **2309**.

As in the joining work area **701** of the first embodiment, images specified by the image specifying part **401** are displayed in the joining work area **2301**. In FIG. **23**, five images (**2351**, **2352**, **2353**, **2354** and **2355**) specified from corresponding reduced images or thumbnails are displayed at a predetermined magnification rate.

As with the mode switching part **702** of the first embodiment, an image position replacing mode **2311** and a joining position specifying mode **2312** are displayed on the mode switching part **2303** as click modes of the pointing device such as the mouse **212**. Since the image position replacing mode **2311** and the joining position specifying mode **2312** have the same contents as the image position replacing mode **708** and the joining position specifying mode **709**, description thereof is omitted here.

Arrangement alternatives selectable as display layouts of images specified by the image specifying part **401** are displayed on the arrangement switching part **2303**. The arrangement switching part **2303** will be described in detail later.

Selectable zoom switching alternatives related to whether an image to be joined with another has been photographed in the zoom mode or not are displayed on the zoom switching part **2304**. When no zoom is used for the photograph, the mode is switched to "standard" **2313**. On the other hand, when the zoom is used for the photograph, the mode is switched to "maximum" **2314**. The zoom mode is thus switched.

Although in this embodiment, switching is enabled by selecting one switching alternative out of two kinds of switching alternatives, more than two zoom modes may be used for switching, depending on the types of digital still cameras and the kinds of zooms. In some types of digital still cameras. the information related to setting of the focal length may be added to the image data. In this case, the focal length may be automatically set by reading the information related to setting of the focal length.

A list of the names of selectable digital still cameras is displayed on the camera switching part **2305**. The operator can select, out of the listed names, the name of a digital still camera with which an image to be joined with other images has been photographed. The camera switching is thus performed.

As with the scale-up button **704** of the first embodiment, the scale-up button **2306** is a button to enlarge the size of images displayed on the joining work area **2301**. The images are enlarged to predetermined magnification each time the scale-up button is pressed, i.e., when the operator moves the cursor onto the scale-up button **2306** to click the button of the mouse **212** or the like one time. The images are thus enlarged on the joining work area **701** at a predetermined magnification rate, and displayed on the joining work area **2301**. This makes it easy for the operator to specify joining points.

The scale-down button **2307** is a button, as similar to the scale-down button **705** of the first embodiment, to reduce the images, in a way opposite to the scale-up button **2306**, to predetermined magnification identical to that of the scale-up button **2306**, according to the number of times the button is pressed. If the scale-down button **2307** is pressed as many times as the scale-up button **2306** is pressed, the images will be returned to the original size.

The start button **2308** is similar to the start button **706** of the first embodiment. to instruct the start of joining processing of the images. Since no joining points have been specified yet, the start button **2308** is grayed out, and pressing the start button **2308** is inhibited.

The cancel button **2309** is similar to the cancel button **707** of the first embodiment, to instruct cancellation of the joining processing. If the cancel button **2309** is pressed, the joining processing currently being performed is stopped, and the joining window **2300** is closed.

Further, since joining points need to be specified by the joining point specifying part **403** for each pair of the adjacent images displayed on the joining work area **2301**, the images must be displayed in such a layout as to join the images in that order. For this reason, the image arranging part **402** performs position replacement processing of the images. The position replacement processing of the images is performed in the same manner as that in the first embodiment and therefore description thereof is omitted here.

FIG. **24** is an illustration showing another example of the display screen on the display part **308** of the image processing apparatus according to the fifth embodiment. In FIG. **24**, the click mode on the mode switching part **2302** is switched from the image position replacing mode **2311** to the joining position specifying mode **2312**. Then adjacent images in the joining work area **2301** are compared to specify, with the pointing device such as the mouse **212**, respective characteristic points at which an identical image character appears on both images. FIG. **24** shows a case where connection lines **2361**, **2362**, **2363** and **2364** are drawn as the specification results of the characteristic points. For example, the connection line **2361** connects the characteristic points of the bow appearing on both images **2351** and **2352**.

When one image differs in brightness from another, the brightest image is used to standardize the brightness of the other images thereto. Alternatively, the leftmost image may be used to standardize the brightness of the other images, or any image selected by the operator may be used to standardize the brightness of the other images.

Since the connection lines **2361**, **2362**, **2363** and **2364** are drawn in the same manner as the connection line **1621** is drawn in the second embodiment, description of the drawing method is omitted here. Further, the image joining method is also the same as that in the first embodiment and therefore description thereof is omitted as well. After completion of drawing all the connection lines, the start button **2308** enters a state in which the operator can press it. Pressing the start button **2308** allows the start of image joining processing.

Next, arrangement switching processing executed by the arrangement switching part **2303** is described. FIGS. **25** through **32** are illustrations showing examples of displayed modes on the arrangement switching part **2303** of the image processing apparatus according to the fifth embodiment, and arrangements or layouts of images in the joining work area **2301**. In FIGS. **25a** through **32a** show examples of displayed modes on the arrangement switching part **2303**, and FIGS. **25b–32b**, and FIGS. **25c–32c**, show variations of image arrangements in the joining work area **2301**.

FIG. **25a** shows displayed modes on the arrangement switching part **2303** when two images are specified. When

two images are specified, there are two arrangement modes, a mode for arranging the two images laterally (2 laterally×1 vertically), and a mode for arranging the two images vertically (1 laterally×2 vertically). FIG. 25b shows an image arrangement in the joining work area 2301 when one arrangement alternative "2 laterally×1 vertically" is specified. FIG. 25c shows another image arrangement in the joining work area 2301 when the other arrangement alternative "1 laterally×2 vertically" is specified.

FIG. 26 shows a case where three images are specified, FIG. 27 shows a case where four images are specified, FIG. 28 shows a case where five images are specified, FIG. 29 shows a case where six images are specified, FIG. 30 shows a case where seven images are specified, FIG. 31 shows a case where eight images are specified and FIG. 32 shows a case where nine images are specified.

For landscape type images in FIGS. 27a to 32a, the word "panorama" is specially added so that the operator can see it at a glance. Further, since in the embodiment the image arrangement is decided based on the case where a maximum of three images can be arranged both in the vertical direction and in the lateral direction, arrangement alternatives for arranging four or more images in the vertical direction or in the lateral direction are not displayed except in respective cases of panorama. For example, when eight images are specified, arrangement alternatives "4 laterally×2 vertically" and "2 laterally×4 vertically" are not displayed in FIG. 31a. Such arrangement alternatives, however, may be displayed as required.

Next, camera switching processing executed by the camera switching part 2305 is described. FIG. 33 is a flowchart showing processing steps of switching the camera mode in the image processing apparatus according to the fifth embodiment. In the flowchart of FIG. 33, the number of pixels for an image is first acquired from the image data storage part 104 (step S3301). It is then determined, from the acquired information on the number of pixels, whether a digital still camera or cameras different in the number of pixels from the photographed image exist in a list or not (step S3302).

If any mismatched digital still cameras do not exist in step S3302 (step S3302 is negative), the procedure shifts to step S3304 in which all the digital still cameras previously registered in the list of digital still cameras are displayed. On the other hand, if a mismatched digital still camera or cameras exist (step S3302 is affirmative), all the names of the mismatched digital still cameras are deleted from the list (step S3303), and the updated list in which all the mismatched camera names have been deleted is displayed (step S3304).

As discussed above, according to the fifth embodiment, when the operator wants to take a picture of a landscape type scene, he or she has only to photograph plural images while changing the position of the digital still camera slightly in the lateral direction so that the plural images can be joined together to form a panorama image.

Further, since proper arrangement alternatives are displayed based on the number of photographed images, the image arrangement can be performed efficiently. Furthermore, since the number of pixels for an image photographed is acquired and only the digital still cameras capable of photographing an image corresponding to the number of pixels are displayed, erroneous selection of a digital still camera different from the digital still camera used for photographing the corresponding image can be avoided.

Herein below, description will be made to image editing related to correction of image distortion realized by the present invention. Since the general structure of the illustrated-document creating system including the image processing apparatus and the hardware configuration of the image processing apparatus 100 for correcting image distortion are substantially the same as those used in the above-described embodiments for joining plural images together to form an image picture, description thereof is omitted here. Further, since parts in the image processing apparatus 100 other than the image altering part 304 and the display control part 307 are substantially the same as those used in the above-described embodiments for joining plural images together to form an image picture, description thereof is omitted as well.

Sixth Embodiment

First, the arrangements of the image altering part 304 and the display control part 307 are described in more detail. FIG. 34 is a functional block diagram showing the arrangements of the image altering part 304, the display control part 307 and the surroundings in the image processing apparatus according to the present invention for correcting image distortion. As shown in FIG. 34, the image altering part 304 includes an image specifying part 2401, an image arranging part 2402, an identical point specifying part 2403 and a distortion correcting part 2404.

At least two images, which are photographed by slightly changing the photographing position and for which the operator desires to correct distortion, are specified by the image specifying part 2401. The image specifying part 2401 specifies images, for which the operator desires to correct distortion, in accordance with an operating instruction from the operation guidance part 301.

The image arranging part 2402 arranges the images specified by the image specifying part 2401. At least two images photographed by slightly changing the photographing position are arranged vertically or laterally so that the identical point specifying part 2403 can easily specify an identical point on adjacent images.

The identical point specifying part 2403 specifies any one identical point for each image displayed on the display screen of the display part 308 under control of the display control part 307. The identical point specifying part 2403 specifies, in accordance with an operating instruction from the operation guidance part 301, an identical point the operator desires to specify.

The processing contents of the image specifying part 2401, the image arranging part 2402 and the identical point specifying part 2403 will be described later.

The distortion correcting part 2404 corrects distortion of an image by referring to the identical point specified by the identical position specifying part 2403. Images photographed by an image pick-up device such as a digital still camera or video camera may include geometrical distortion due to image formation in a position deviated from the original position of the image under the influence of so-called distortion aberration of the lens system. To correct image distortion, a method such as, for example, one described in Japanese patent application laid-open publication No. 9-294225 (Japanese patent application No. 8-2732949) of the same applicant, can be used.

The method is characterized in that plural images including an identical point picked up from one point are used to detect plural sets of corresponding observing points from these images and measure angles of the observation points

with respect to an optical axis of the image pick-up system, thus estimating a parameter for correcting distortion of the images based on the angle information obtained.

A file name is assigned to the image of which the distortion has been corrected by the distortion correcting part 2404 and the image is stored into the image data storage part 104 based on the file name.

The image specifying part 2401, the image arranging part 2402, the identical point specifying part 2403 and the distortion correcting part 2404 are embodied, respectively, by the CPU 201 or the like executing command processing according to commands written in programs such as an OS and an application program recorded on recording media such as the ROM 202, the RAM 203, the hard disk 205 or the floppy disk 207.

The display control part 307 controls the display part 308 to display, as illustrated in FIG. 36, a distortion correcting window 700 and images, specified by the image specifying part 2401 and arranged by the image arranging part 2402, io a distortion correcting work area 701 of the distortioo correcting window 700.

The display contents of the display part 308 is substantially the same as the case where plural images are joined together to form an image picture and therefore detailed descriptioo thereof is omitted.

Referring to FIG. 35, as with the description with respect to FIG. 5 of the first embodiment in which plural images are joined together to form an image picture, two images are specified from corresponding reduced images or thumbnails in the reduced image display area 502. The method to specify the images is the same as that shown in the first embodiment in which plural images are joined together to form an image picture.

In FIG. 35, two reduced images or thumbnails 601 and 602 are specified as images of which the distortion is to be corrected. The reduced images specified are discriminated from the other images by inversely (negatively) displaying the file names, or enclosing the reduced images with a bold frame, so that the operator can recognize the reduced images specified.

After completion of specifying the reduced images, the operator moves the cursor to an "image correction" menu 603 on the menu bar in FIG. 35, clicks the button of the mouse 212 or the like, and further clicks an "distortion correction" menu 604 displayed as one of pull-down menus to select the distortion correcting function. Thus, the distortion correcting window 700 is popped up and displayed as shown in FIG. 36.

Next, the processing contents of the image arranging part 402 are described. FIG. 36 is an illustration showing anotber example of the display screen on the display part 308 according to the sixth embodiment. The distortion correcting window 700 includes the distortion correcting work area 701, the scale-up button 704, the scale-down button 705, the start button 706 and the cancel button 707.

Images specified by the image specifying part 2401 are displayed in the distortion correcting work area 701. In FIG. 36, images 751 and 752 identical to the reduced images 601 and 602 specified in FIG. 35 are displayed at a predetermined magnification rate. As apparent from FIG. 36, the billboard for a coffee shop is distorted so as to have reduced magnification in a direction to away from the center of the image. This distortion becomes noticeable in regions close to vertical or lateral edges.

Since the scale-up button 704 and the scale-down button 705 perform substantially the same functions, respectively, as described in the embodiments for joining plural images together to form an image picture, description thereof is omitted here.

The start button 706 instructs the start of correction of image distortion. In the state illustrated in FIG. 36, since joining points have not been specified yet, the start button 706 is grayed out. and pressing the start button 706 is inhibited.

The cancel buttoo 707 instructs cancellation of the distortion correction processing. If the cancel button 707 is pressed, the distortion correction processing currently being performed is stopped, and the distortion correcting window 2300 is closed.

Next, description is made to the processing contents of tbe identical point specifying part 2403. FIG. 37 is an illustration showing still another example of the display screen on the display part of the image processing apparatus according to the sixth embodiment.

In FIG. 37, adjacent images in the distortion correcting work area 701 are compared to specify, with the pointing device such as the mouse 212, an identical point appearing in each of the adjacent images, i.e., a characteristic point in a common image pattern appearing oil both images. To specify the characteristic identical point accurately on each image, the images should be enlarged to a certain extent as sbown in FIG. 37.

Specifically, the star-shape symbol marks 761 and 762, located on the left hand of the billboard for the coffee shop appearing on both images 751 and 752, are suitable as characteristic identical points to be specified. Then, joining points are specified by moving the cursor, for example, to respective tips 771 and 772 of the star-shape symbol marks 761 and 762, and clicking the button of the mouse 212 or the like. Coordinate data indicative of the joining points specified are stored in a storage provided inside tbe joining point specifying part 2403.

After completion of specifying the identical points. the operator presses the start button 706 to start execution to the distortion correction processing. A window, though not shown here, is opened with a message indicating "Distortion correction processing is completed". When an "OK" button in the window is clicked, the distortion correction processing is ended.

Next, description is made to a sequence of processing steps executed by the image altering part 304 and the display control part 307 according to the sixth embodiment. FIG. 38 is a flowchart showing a sequence of processing steps executed by the image altering part 304 and the display control part 307 of the image processing apparatus 100 according to the sixth embodiment. In the flowchart of FIG. 38, it is first determined whether two or more images are specified or not (step S901). The operation remains in step S901 until two or more images are specified (until step S901 becomes affirmative), and it is then determined whether distortion correction is instructed or not (step S902).

If distortion correction is not instructed in step S902 (step S902 is negative), it is determined whether other instructions such as deletion of images are given or not (step S903). If no other instruction is given here (step S903 is negative), the procedure returns to step S901, and the subsequent processing steps are repeated. If any other instruction is given in step S903 (step S903 is affirmative), this operation is ended after execution of the corresponding processing (step S904).

If distortion correction is instructed in step S902 (step S902 is affirmative), arrangement processing is executed for the specified images (step S910). The image arrangement procedures will be described in detail later.

It is next determined whether the image arrangement is to be altered or not (step S940). If alteration in arrangement is required (step S940 is affirmative), the procedure returns to step S910 in which the images arc rearranged. If alteration is not required in step S940 (step S940 is negative), it is determined whether identical points are specified or not (step S950). If any set of identical points is specified (step S950 is affirmative), coordinate data of the identical points specified are saved (step S965). The processing steps S950 througb S970 are repeated until all the identical points are specified. When all the identical points have been specified (step S970 is affirmative), it is further determined whether specification of any set of identical points is to be altered or not (step S980).

If determination is made in step S980 that a specification of any set of identical points is to be altered (step S980 is affirmative), the procedure returns to step S950. On the other hand, if determination is not made in step S980 that specification of any set of identical points is to be altered (step S1980 is negative), it is determined whether the start button is pressed or not (step S981). If the start button is pressed (step S981 is affirmative), the distortion correction is executed (step S982), and the results of the distortion correction is stored (step S983) to end all the processing.

FIG. 39 shows a resulting image for which the distortion correction has been executed. As apparent from FIG. 39, execution of the distortion correction results in correction of the distortion appearing on the lower side of the billboard for the coffee shop.

If the start button is not pressed in step S981 (step 981 is negative), it is determined whether alteration in image arrangement is required or not (step S990). If alteration in image arrangement is required (step S990 is affirmative), the procedure returns to step S910 and the subsequent processing steps are repeated. On the other hand, if alteration in image arrangement is not required (step S990 is negative), the procedure returns to step S980 in which determination is made as to whether any set of identical points should be altered or not. After that, the subsequent processing steps arc repeated.

Next, the image arrangement processing executed at step S910 is described in detail. FIG. 40 is a flowchart showing processing steps executed by the image arranging pail 2402 of the image processing apparatus 100 according to tbe sixth embodiment. If distortion correction is instructed in step S902 of tbe flowchart of FIG. 38 (step S902 is affirmative), determination is made in the flowchart of FIG. 40 as to wbether an enlargement of the images is possible or not (step S915). If possible (step S915 is affirmative), determination is made as to whether the enlargement is instructed or not (step S916). If instructed (step S916 is affirmative), the enlargement is performed (step S917). On the other hand, if it is not possible to enlarge the images (step S915 is negative), or if the enlargement is not instructed (step S916 is negative), the procedure goes to the next step without execution of any processing.

It is next determined whether a reduction of the images is possible or not (step S918). If possible (step S918 is affirmative), determination is made as to whether the reduction is instructed or not (step S919). If instructed (step S919 is affirmative), the reduction is performed (step S920). On the other hand, if it is not possible to reduce the images (step S918 is negative), or if the reduction is not instructed (step S919 is negative), the procedure goes to the next step, i.e., step 940, without execution of any processing.

As discussed above, according to the six embodiment of the present invention, when correction of image distortion is performed, specification and arrangement of images, and specification of identical points for adjacent images are easily done.

Seventh Embodiment

Although in the sixth embodiment an identical point in each image is specified by moving a cursor to the point and then clicking the button of the mouse 212 or the like, the identical point may be specified using a line, i.e., by specifying identical points on two or more adjacent images in a drag-and drop operation of the mouse 212 or the like, as discussed in the following seventh embodiment.

Since the general structure of the illustrated-document creating system including an image processing apparatus according to the seventh embodiment of the present invention, and the hardware configuration of the image processing apparatus 100 are substantially the same as those of the sixth embodiment, description thereof is omitted here. Further, since the image processing apparatus 100 includes substantially the same parts as those of the sixth embodiment except tbe image altering part 304 and the display control part 307, the parts common to those of the sixth embodiment are also not described bere.

Next, the image altering part 304 is described. FIG. 41 is a functional block diagram showing the arrangement of the image altering part 304 and the surroundings in the image processing apparatus 100 according to the seventh embodiment of the present invention. As shown in FIG. 41, the image altering part 304 includes an image specifying part 2501, an image arranging part 2502, an identical point specifying part 2503, a distortion correcting part 2504 and a connection line drawing part 2505. Since parts other than the identical point specifying part 2503 and the connection line drawing part 2505 are substantially the same as those of the sixtb embodiment, description thereof is omitted.

The identical point specifying part 2503 has substantially the same structure as that of the identical point specifying part 2403 of the sixth embodiment, in which any one point is specified for each image so that images displayed on the display screen of the display part 308 under control of the display control part 307, can be joined by referring to the point, but differs from the identical point specifying part 2403 in method of specifying the point. The connection line drawing part 2505 draws a connection line between the locations specified by the identical point specifying part 2503. The processing contents of the identical point specifying part 2503 and the connection line drawing part 2505 will be described in detail later.

The image specifying part 2501, the image arranging part 2502, the identical point specifying part 2503, the distortion correcting part 2504 and the connection line drawing part 2505 are embodied, respectively, by the CPU 201 or the like executing command processing according to commands written in programs such as an OS and an application program recorded on recording media such as the ROM 202, tbe RAM 203, the hard disk 205 or the floppy disk 207.

The display control part 307 controls tbe display part 308 to display not only images arranged by the arranging part 2502, but also a connection line 1321 drawn by the connection line drawing part 2505 as shown in FIG. 42.

Next, description is made to specification processing of identical points and drawing processing of a connection line executed by the identical point specifying part 2503 and the connection line drawing part 2505. FIG. 42 is an illustration showing an example of a display screen on the display part 308 of tbe image processing apparatus according to the

seventh embodiment. In FIG. 42, images 1301 and 1302 are compared to specify a characteristic point in common image patterns appearing on both images. In the example illustrated in FIG. 42, the operator first moves the cursor to one point 1311 on the image 1301.

The operator then presses the button of the mouse 212 or the like. and moves (drags) the cursor to the other point 1312 on the image 1302 by moving the mouse 212 with maintaining pressed state of the button. The connection line drawing part 2505 is synchronized with the movement of the cursor to draw the connection line 1321 on the coordinates identical to the cursor path on the screen. When the cursor reaches the point 1312, the operator releases (drops) the pressed state of the button. The connection line 1321 drawn by the connection line drawing part 2505 is thus fixed.

The identical points are thus specified. Coordinate data of the identical points specified are saved (stored) in a storage provided inside the identical point specifying part 2503. After completion of the specification processing of identical points, the operator can press the start button to start execution of distortion correction processing.

Thus, the identical points can be specified by the simplest way in operation to move the cursor to a point in one image by operating the mouse or the like, press the button of the mouse or the like, move the cursor while pressing the button to a corresponding position in the another image, and then release the pressed button. The connection line 1321 is preferably drawn by a method such as one described in the second embodiment for joining plural images.

Next, description is made to a sequence of processing steps executed by the image altering part 304 and the display control part 307 according to the seventh embodiment. FIG. 43 is a flowchart showing part of processing steps executed by the image altering part 304 and the display control part 307 of the image processing apparatus 100 according to the seventh embodiment. Since the flowchart of FIG. 43 executes substantially the same processing steps as those from S901 to S940 and those from S965 to S990 in the flowchart of FIG. 38 according to the sixth embodiment, the common steps and their description are omitted.

In step S940 of the flowchart of FIG. 38 according to the sixth embodiment, if alteration in image arrangement is not required (step S940 is negative), determination is made in the flowchart of FIG. 43 as to whether the button of the mouse 212 or the like is pressed or not (step S951). If the button is pressed (step S951 is affirmative), it is determined whether the cursor is positioned on an image or not (step S952). If the cursor is not positioned on any image (step S952 is negative), an error indication is given (step S953) and the procedure returns to step S951. On the other hand, if the cursor is positioned on an image (step S953 is affirmative), drawing of a connection line is started at the point (step S954).

After that, the operation remains in step S955 until the button of the mouse 212 or the like is released. When the button is released (step S955 becomes affirmative), the drawing of the connection line is ended (step S961). After that, the procedure goes to step S965 of FIG. 38 according to the sixth embodiment.

As discussed above, according to the sixth embodiment, a connection line is drawn between identical points specified, so that the operator can not only specify the identical points as if he or she drew a line by hand, but also recognize instantaneously whether the identical points are specified or not.

Eighth Embodiment

Although the above sixth and seventh embodiments do not describe a case where a set of identical points once specified is altered, the set of identical points already specified may be released when a set of identical points is specified for images for which another set of identical points has already been specified, as described in the following eighth embodiment.

Since the general structure of the illustrated-document creating system including an image processing apparatus according to the eighth embodiment of the present invention and the hardware configuration of the image processing apparatus 100 are substantially the same as those of the sixth embodiment, description thereof is omitted here. Further, since the image processing apparatus 100 includes substantially the same parts as those of the sixth embodiment except the image altering part 304, the parts common to those of the sixth embodiment are also not described here.

Next, the image altering part 304 is described. FIG. 44 is a functional block diagram showing the arrangement of the image altering part 304 and the surroundings in the image processing apparatus 100 according to the eighth embodiment of the present invention. As shown in FIG. 44, the image altering part 304 includes an image specifying part 2601, an image arranging part 2602, an identical point specifying part 2603, a distortion correcting part 2604, a connection line drawing part 2605 and an identical point specification releasing part 2606.

Since parts other than the identical point specifying part 2603, the connection line drawing part 2605 and the identical point specification releasing part 2606 are substantially the same as those of the sixth embodiment, and the connection line drawing part 2605 is substantially the same as that of the seventh embodiment, description thereof is omitted.

The identical point specifying part 2603 may be either the identical point specifying part 2403 of the sixth embodiment, or the identical point specifying part 2503 of the seventh embodiment. The identical point specification releasing part 2606 releases specification of the previous set of identical points when a set of identical points is specified for a pair of images for which another set of identical points has already been specified. The processing contents of the identical point specification releasing part 2606 will be described in detail later.

The image specifying part 2601, the image arranging part 2602, the identical point specifying part 2603. the distortion correcting part 2604, the connection line drawing part 2605 and the identical point specification releasing part 2606 are embodied, respectively, by the CPU 201 or the like executing command processing according to commands written in programs such as an OS and an application program recorded on recording media such as the ROM 202, the RAM 203. the hard disk 205 or the floppy disk 207.

Next, description is made to releasing processing of a set of identical points executed by the identical point specification releasing part 2606. When a set of identical points is specified for a pair of images, the identical point specification releasing part 2606 recognizes whether another set of identical points has already been specified for the images by referring to whether or not coordinate data of the corresponding identical points are stored in a storage provided inside the identical point specifying part 2603.

When a new set of identical points is specified, the identical point specification releasing part 2606 releases the previous identical points by deleting corresponding coordinate data stored, and stores the set of identical points newly specified. Thus, the identical points can be easily changed. The identical point specification releasing part 2606 also deletes a connection line 1321, if any, drawn between the identical points already specified.

Next, description is made to a sequence of processing steps executed by the image altering part **304** and the display control part **307** according to the eighth embodiment. FIG. **45** is a flowchart showing a part of processing steps executed by the image altering part **304** and the display control part **307** according to the eighth embodiment.

Since the flowchart of FIG. **45** executes substantially the same processing steps as those from **S901** to **S940** and those from S965 to S990 in the flowchart of FIG. **38** according to the sixth embodiment, the common steps and their description are omitted. Further, the flowchart of FIG. **45** also executes substantially the same processing steps as those from **S951** to **S956** and **S965** in the flowchart of FIG. **43**, and therefore description thereof is omitted as well.

The operation remains in step **S955** until the button of the mouse **212** or the like is released. If the button is released (step **S955** becomes affirmative, it is then determined whether identical points are specified for the plural images or not (step **S956**). If the identical points are not specified for the plural images (step **S956** is negative), the procedure shifts to step **S961** without execution of any processing.

On the other hand, if the identical points are specified (step **S956** is affirmative), the identical points are released (step **S957**). The connection line drawn between the identical points released is then deleted (step **S958**), and the procedure goes to step S1361.

As discussed above, according to the eighth embodiment, when a set of identical points is specified for images for which another set of identical points has already been specified, the identical point specification releasing part **2606** releases the previous set of identical points already specified, so that when specifying a new set of identical points, the operator can change the specification of identical points easily and efficiently in the same operation when specifying a set of identical points for the first time without the need to release the specification of the previous set of identical points.

Ninth Embodiment

Although the above sixth to eighth embodiments for correcting image distortion have been made for images photographed with a digital still camera **213** having a fixed focal length, i.e., the above embodiments assume that the focal length is invariable, when the images for correcting image distortion are those photographed with a digital still camera **213** having variable focal lengths, the focal length may be set for proper distortion correction of images, as discussed in the following ninth embodiment.

Since the general structure of the illustrated-document creating system including an image processing apparatus according to the ninth embodiment of the present invention and the hardware configuration of the image processing apparatus **100** are substantially the same as those of the sixth embodiment, description thereof is omitted here. Further, since the image processing apparatus **100** includes substantially the same parts as those of the sixth embodiment except the image altering part **304**, the parts common to those of the sixth embodiment are also not described here.

Next, the image altering part **304** is described. FIG. **46** is a functional block diagram showing the arrangement of the image altering part **304** and the surroundings in the image processing apparatus **100** according to the ninth embodiment of the present invention. As shown in FIG. **46**, the image altering part **304** includes an image specifying part **2701**, an image arranging part **2702**, an identical point specifying part **2703**. a distortion correcting part **2704**, a connection line drawing part **2705**, an identical-point specification releasing part **2706** and a focal length setting part **2707**.

The image specifying part **2701**, the image arranging part **2702**, the identical point specifying part **2703**, the connection line drawing part **2705** have substantially the same structure as those of the image specifying parts **2401**, **2501** and **2601**, the image arranging parts **2402**, **2502** and **2602**, the identical point specifying parts **2403**, **2503** and **2603**, and the connection line drawing part **2405**, **2505** and **2605** according to the sixth to eighth embodiments, respectively. Such common parts are not described here.

The focal length setting part **2707** sets the focal length of an image, photographed with a digital still camera **213** or the like, in accordance with an operating instruction from the operation guidance part **301**. The focal length may be set by directly inputting a numerical value for the focal length, or otherwise, from a table related to camera types and their focal lengths, which is pre-stored, by inputting information regarding the camera type, whether a zooming lens is used and the like. The processing contents of the focal length setting part **2707** will be described in detail later.

The image specifying part **2701**, the image arranging part **2702**, the identical point specifying part **2703**, the distortion correcting part **2704**, the connection line drawing part **2705**, the identical point specification releasing part **2706** and the focal length setting part **2707** are embodied, respectively, by the CPU **201** or the like executing command processing according to commands written in programs such as an OS and an application program recorded on recording media Such as the ROM **202**, the RAM **203**, the hard disk **205** or the floppy disk **207**.

Next, description is mad e to focal-length setting processing executed by the focal length setting part **2707**. FIG. **47** is an illustration showing an example of a display screen on the display part **308** of the image processing apparatus **100** according to the ninth embodiment. In FIG. **47**, a distortion correcting window **1800** includes a distortion correcting work are a **1801**, a zoom switching part **1802**, a camera switching part **1803**, a scale-up button **1804**, a scale-down button **1805**, a start button **1806** and a cancel button **1807**.

The distortion correcting work area **1801**, the scale-up button **1804**, the scale-down button **1805**, the start button **1806** and the cancel button **1807** have substantially the same structure as those of the distortion correcting work area **701**, the scale-up button **704**, the scale-down button **705**, the start button **706** and the cancel button **707** according to the sixth embodiment, respectively. Such common parts are not described here.

The zoom switching part **1802** displays selectable zoom switching, alternatives related to whether an image to be joined with another has been photographed in the zoom mode or not. When no zoom is used for the image, the mode is switched to "standard" **S1813**. On the other hand, when the zoom is used for the image, the mode is switched to "maximum" **1814**. The zoom mode is thus switched.

Although in the embodiment switching is enabled by selecting one switching alternative out of two kinds of switching alternatives, more than two zoom modes may be used for switching over among them depending on the types of digital still cameras and the kinds of zooms. In some types of digital still cameras, these information related to setting of the focal length may be added to respective image data. In this case, the focal length may be automatically set by reading the information related to setting, of the focal length, which is added to respective image data.

The camera switching part **1803** displays a list of the names of selectable digital still cameras. The operator can

select, out of the listed names, the name of a digital still camera with which an image to be joined with other images has been photographed. The camera switching is thus performed.

Next, description is made to a sequence of processing steps executed by the image altering part **304** and the display control part **307** according to the ninth embodiment. FIG. **48** is a flowchart showing a part of processing steps executed by the image altering part **304** and the display control part **307** of the image processing apparatus **100** according to the ninth embodiment.

Since the flowchart of FIG. **48** executes substantially the same processing steps as those from **S901** to **S910** and those from **S940** to **S990** in the flowchart of FIG. **38** according to the sixth embodiment, the marks of the common steps and their description are omitted. The flowchart of FIG. **48** also executes substantially the same processing, steps as those from **S911** to **S920** in the flowchart of FIG. **40** according to the sixth embodiment and therefore description thereof is omitted as well.

In the flowchart of FIG. **48**, if step **S919** is negative or after completion of step **S920**, determination is made as to whether focal-length setting processing is instructed or not (step **S931**). If instructed (step **S938** is affirmative), the focal-length setting processing is performed (step **S932**). On the other hand, if not instructed (step **S931** is negative), the procedure goes to the next step, i.e., step **S940**, without execution of any processing.

As discussed above, according to the ninth embodiment, the focal length setting part **2707** sets the focal length with which an image has been input, while the distortion correcting part **2704** corrects distortion of the image based on the focal length set for use in distortion correction processing of the image. This makes it possible to edit images without occurrence of distortion even if the images have been input by an input device (an image pick-up device) with different focal lengths.

Numerous additional modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the present invention may be practiced otherwise than as specifically described herein.

This document claims priority and contains subject matter related to Japanese patent applications No. 10-14413, No. 10-196278, and No. 10-196280 filed in the Japanese Patent Office on Apr. 10, 1998, Jul. 10, 1998 and Jul. 10, 1998, respectively, and the entire contents of which are hereby incorporated by reference.

What is claimed is:

1. An image processing apparatus, comprising:

a display device configured to display images on a display screen such that the images can be edited and processed;

image specifying means for specifying at least two images to be joined together;

image arranging means for arranging the images specified by said image specifying means in a desired order;

display control means for controlling said display device to display the images arranged by said image arranging means;

joining point specifying means for specifying respective joining points for at least two of said specified images;

connection line drawing means for drawing a connection line between joining points specified by said joining point specifying means, and

joining means for joining the at least two specified images by referring to the joining points specified by said joining point specifying means;

wherein said display control means controls said display device to display both the images arranged by said image arranging means and the connection line drawn by said connection line drawing means.

2. An image processing apparatus, comprising:

a display device configured to display images on a display screen such that the images can be edited and processed;

image specifying means for specifying at least two images to be joined together;

image arranging means for arranging the images specified by said image specifying means in a desired order;

display control means for controlling said display device to display the images arranged by said image arranging means;

joining point specifying means for specifying respective joining points for at least two of said specified images;

joining means for joining the at least two specified images by referring to the joining points specified by said joining point specifying means; and

joining-point specification releasing means for releasing specification of a previous specified set of joining points for a pair of images when a new set of joining points is specified for the pair of images.

3. The image processing apparatus as set forth in claim **1**, further comprising:

focal length setting means for setting a focal length of an image to be specified; and

image correcting means for correcting a specified image based on the focal length set by said focal length setting means.

4. The image processing apparatus as set forth in claim **1**, wherein said display control means controls the display device to display the images vertically.

5. The image processing apparatus as set forth in claim **1**, wherein said display control means controls the display device to display the images horizontally.

6. A method for controlling an image processing apparatus, comprising steps of:

displaying images on a display screen;

specifying at least two images to be joined together;

arranging the images specified in said specifying step in a desired order;

displaying the specified images arranged in said arranging step;

specifying respective joining points for at least two of the specified images;

drawing a connection line between the joining points specified in said joining point specifying step; and

joining the at least two images by referring to the joining points specified in said joining points specifying step;

wherein said arranged images displaying step displays both the images arranged in said arranging step and the connection line drawn in said connection line drawing step.

7. A method for controlling an image processing apparatus, comprising steps of:

displaying images on a display screen;

specifying at least two images to be joined together;

arranging the images specified in said specifying step in a desired order;

displaying the specified images arranged in said arranging step;

specifying respective joining points for at least two of the specified images;

joining the at least two images by referring to the joining points specified in said joining points specifying step; and

releasing specification of a previous specified set of joining points for a pair of images when the specifying step is performed for the pair of images.

8. The method as set forth in claim 6, further comprising steps of:

setting a focal length of an image to be specified; and

correcting the specified image based on the focal length set in said focal length setting step.

9. The method as set forth in claim 6, wherein said step of displaying the arranged images comprises displaying the images vertically.

10. The method as set forth in claim 6, wherein said step of displaying the arranged images comprises displaying the images horizontally.

11. A computer-readable recording medium storing computer instructions for controlling an image processing apparatus to perform the steps of:

displaying images to be specified on a display screen;

arranging specified images in a desired order;

displaying the images arranged in said arranging step;

joining at least two of the images by referring to respective user specified joining points of the images; and

drawing a connection line between the joining points;

wherein said arranged image displaying step displays of the images arranged in said arranging steps and the connection line.

12. A computer-readable recording medium storing computer instructions for controlling an image processing apparatus to perform the steps of:

displaying images to be specified on a display screen;

arranging specified images in a desired order;

displaying the images arranged in said arranging step;

joining at least two of the images by referring to respective user specified joining points of the images; and

releasing specification of a previous specified set of joining points for a pair of images when the specifying step is performed for the pair of images.

13. The computer readable recording medium as set forth in claim 11, the computer instructions further controlling an image processing apparatus to perform the step of:

correcting a specified image based on a focal length of the specified image.

14. The computer readable recording medium as set forth in claim 11, wherein said step of displaying the arranged images comprises displaying the images horizontally.

15. The computer readable recording medium as set forth in claim 11, wherein said step of displaying the arranged images comprises displaying the images vertically.

16. An image processing apparatus, comprising:

a display device configured to display images on a display screen such that the images can be edited and processed;

image specifying means for specifying at least two images photographed at different photographing positions;

image arranging means for arranging the images specified by said image specifying means;

display control means for controlling said display device to display the specified images arranged by said image arranging means;

point specifying means for specifying respective points for at least two of the specified images displayed by said display control means;

connection line drawing means for drawing a connection line between the points specified by said point specifying means;

distortion correcting means for correcting distortion of the at least two images by referring to the points specified by said point specifying means; and

wherein said display control means controls said display device to display both the images arranged by said image arranging means and the connection line drawn by said connection line drawing means.

17. An image processing apparatus, comprising:

a display device configured to display images on a display screen such that the images can be edited and processed;

image specifying means for specifying at least two images photographed at different photographing positions;

image arranging means for arranging the images specified by said image specifying means;

display control means for controlling said display device to display the specified images arranged by said image arranging means;

point specifying means for specifying respective points for at least two of the specified images displayed by said display control means;

distortion correcting means for correcting distortion of the at least two images by referring to the points specified by said point specifying means; and

point specification releasing means for releasing specification of a previous specified set of points for a pair of images when a new set of points is specified for the pair of images.

18. The image processing apparatus as set forth in claim 16, further comprising:

focal length setting means for setting the focal length of the images to be specified;

wherein said distortion correcting means corrects distortion of the specified images based on the focal length set by said focal length setting means.

19. A method for controlling an image processing apparatus, comprising:

displaying images on a display screen;

specifying at least two images photographed at different photographing positions;

arranging the images specified in said image specifying step;

controlling display of the images arranged in said image arranging step;

specifying respective points for at least two of the images displayed in said display control step:

drawing a connection line between the points specified in said point specifying step; and

correcting distortion of the at least two images by referring to the points specified in said point specifying step;

wherein said control step controls display of both the images arranged in said image arranging step and the connection line drawn in said connection line drawing step.

20. A method for controlling an image processing apparatus, comprising:

displaying images on a display screen;

specifying at least two images photographed at different photographing positions; arranging the images specified in said image specifying step;

controlling display of the images arranged in said image arranging step;

specifying respective points for at least two of the images displayed in said display control step;

correcting distortion of the at least two images by referring to the points specified in said point specifying step; and

releasing specification of a previous specified set of points for a pair of images when a given set of points is specified for the pair of images in said point specifying step.

21. The method as set forth in claim 19, further comprising a step of:

setting a focal length of an image to be specified,

wherein said distortion correcting step corrects distortion of the specified image based on the focal length set in said focal length setting step.

22. A computer-readable recording medium storing computer instructions for controlling an image processing apparatus to perform the steps of:

displaying images to be specified on a display screen;

arranging specified images in a desired order;

displaying the images arranged in said arranging step;

correcting distortions of least two of the images by referring to respective user specified points of the images; and

drawing a connection line between the specified points,

wherein said display control step controls display of both the images arranged in said image arranging step and the connection line drawn in said connection line drawing step.

23. A computer-readable recording medium storing computer instructions for controlling an image processing apparatus to perform the steps of:

displaying images to be specified on a display screen;

arranging specified images in a desired order;

displaying the images arranged in said arranging step;

correcting distortions of least two of the images by referring to respective user specified points of the images; and

releasing specification of a previous selected set of points for a pair of images when a new set of points is specified for the pair of images.

24. The computer readable recording medium as set forth in claim 22, the computer instructions further controlling an image processing apparatus to perform the step of:

correcting distortion of a specified image based on the focal length of the image.

25. A computer-readable recording medium storing computer instructions for controlling an image processing apparatus to perform the steps of:

specifying respective joining points for at least two images displayed on a display device;

joining the at least two images by referring to the joining points; and

connection line drawing means for drawing on the display device, a connection line between joining points specified by said joining point specifying means.

26. A computer-readable recording medium storing computer instructions for controlling an image processing apparatus to perform the steps of:

specifying respective joining points for at least two images displayed on a display device;

joining the at least two images by referring to the joining points; and

releasing specification of a previous specified set of joining, points for a pair of images when a new set of joining points is specified for the pair of images.

27. A computer-readable recording medium storing computer instructions for controlling an image processing apparatus to perform the steps of:

specifying respective points for at least two images displayed on a display device;

correcting distortion of the at least two images by referring to the points specified by said point specifying means; and

drawing, on the display device, a connection line between the points specified by said point specifying means.

28. A computer-readable recording medium storing computer instructions for controlling an image processing apparatus to perform the steps of:

specifying respective points for at least two images displayed on a display device;

correcting distortion of the at least two images by referring to the points specified by said point specifying means; and

point specification releasing means for releasing specification of a previous specified set of points for a pair of images when a new set of points is specified for the pair of images.

29. A computer-readable recording medium storing computer instructions for controlling an image processing apparatus to perform the steps of:

displaying images to be specified on a display screen;

displaying the specified images in both a horizontal and a vertical arrangement on the display screen;

displaying the specified images only in a user selected one of the horizontal and vertical arrangements of the specified images;

drawing, on the display screen, a connection line between user specified joining points; and

joining least two of the images displayed in said step of displaying the specified images only in a user selected arrangement, by referring to respective said user specified joining points of the images.

30. A computer-readable recording medium storing computer instructions for controlling an image processing apparatus to perform the steps of:

displaying images to be specified on a display screen;

displaying the specified images in both a horizontal and a vertical arrangement on the display screen;

displaying the specified images only in a user selected one of the horizontal and vertical arrangements of the specified images;

drawing, on the display screen, a connection line between user specified points; and

correcting distortion of least two of the images displayed in said step of displaying the specified images only in a user selected arrangement, by referring to respective said user specified points of the images.

31. The image processing apparatus as set forth in claim 1, further comprising:

means for standardizing the brightness of the specified images by reference to the brightest one of the specified images.

32. The image processing apparatus as set forth in claim 1, further comprising:

means for standardizing the brightness of the specified images by reference to the first specified one of the specified images.

33. The method as set forth in claim 6, further comprising the step of:

standardizing the brightness of the specified images by reference to the brightest one of the specified images.

34. The method as set forth in claim 6, further comprising the step of:

standardizing the brightness of the specified images by reference to the first specified one of the specified images.

35. The computer readable recording medium as set forth in claim 11, the computer instructions further controlling the image processing apparatus to perform the step of:

standardizing the brightness of the specified images by reference to the brightest one of the specified images.

36. The computer readable recording medium as set forth in claim 11, the computer instructions further controlling the image processing apparatus to perform the step of:

standardizing the brightness of the specified images by reference to the first specified one of the specified images.

37. The image processing apparatus as set forth in claim 16, further comprising:

means for standardizing the brightness of the specified images by reference to the brightest one of the specified images.

38. The image processing apparatus as set forth in claim 16, further comprising:

means for standardizing the brightness of the specified images by reference to the first specified one of the specified images.

39. The method as set forth in claim 19, further comprising the step of:

standardizing the brightness of the specified images by reference to the brightest one of the specified images.

40. The method as set forth in claim 19, further comprising the step of:

standardizing the brightness of the specified images by reference to the first specified one of the specified images.

41. The computer readable recordings medium as set forth in claim 22, the computer instructions further controlling the image processing apparatus to perform the step of:

standardizing the brightness of the specified images by reference to the brightest one of the specified images.

42. The computer readable recording medium as set forth in claim 22, the computer instructions further controlling the image processing apparatus to perform the step of:

standardizing the brightness of the specified images by reference to the first specified one of the specified images.

43. The image processing apparatus as set forth in claim 1, wherein said connection line has a characteristic such that it can be readily discriminated from the remainder of the image.

44. The image processing apparatus as set forth in claim 43, wherein said characteristic is color.

45. The image processing apparatus as set forth in claim 43, wherein said characteristic is line thickness.

46. The image processing apparatus as set forth in claim 43, wherein said characteristic is operator selectable.

47. The image processing apparatus as set forth in claim 43, wherein said characteristic is automatically selected by taking into account a color used in the image.

48. The method as set forth in claim 14, wherein said connection line has a characteristic such that it can be readily discriminated from the remainder of the image.

49. The method as set forth in claim 48, wherein said characteristic is color.

50. The method as set forth in claim 48, wherein said characteristic is line thickness.

51. The method as set forth in claim 48, wherein said characteristic is operator selectable.

52. The method as set forth in claim 48, wherein said characteristic is automatically selected by taking into account a color used in the image.

53. The computer readable recording medium as set forth in claim 22, wherein said connection line has a characteristic such that it can be readily discriminated from the remainder of the image.

54. The computer readable recording medium as set forth in claim 53, wherein said characteristic is color.

55. The computer readable recording medium as set forth in claim 53, wherein said characteristic is line thickness.

56. The computer readable recording medium as set forth in claim 53, wherein said characteristic is operator selectable.

57. The computer readable recording medium as set forth in claim 53, wherein said characteristic is automatically selected by taking into account a color used in the image.

58. The image processing apparatus as set forth in claim 1, wherein said image arranging means comprises means for displaying options for arranging the specified images in one or more arrangements, and means for displaying the images arranged according to a selected one of said options.

59. The method as set forth in claim 6, wherein said image arranging step comprises displaying options for arranging the specified images in one or more arrangements, and then displaying the images arranged according to a selected one of said options.

60. The computer readable recording medium as set forth in claim 11, wherein said image arranging step comprises displaying options for arranging the specified images in one or more arrangements, and then displaying the images arranged according to a selected one of said options.

61. The image processing apparatus as set forth in claim 16, wherein said image arranging means comprises means for displaying options for arranging the specified images in one or more arrangements, and means for displaying the images arranged according to a selected one of said options.

62. The method as set forth in claim 19, wherein said image arranging step comprises displaying options for arranging the specified images in one or more arrangements, and then displaying the images arranged according to a selected one of said options.

63. The computer readable recording medium as set forth in claim 22, wherein said image arranging step comprises displaying options for arranging the specified images in one or more arrangements, and then displaying the images arranged according to a selected one of said options.

* * * * *

US006583813B1

(12) **United States Patent**
Enright et al.

(10) Patent No.: **US 6,583,813 B1**
(45) Date of Patent: **Jun. 24, 2003**

(54) **SYSTEM AND METHOD FOR CAPTURING AND SEARCHING IMAGE DATA ASSOCIATED WITH TRANSACTIONS**

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(73) Assignee: **Diebold, Incorporated**, North Canton, OH (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/414,249**

(22) Filed: **Oct. 7, 1999**

Related U.S. Application Data

(60) Provisional application No. 60/103,731, filed on Oct. 9, 1998.

(51) Int. Cl.^{7} **H04N 7/18**
(52) U.S. Cl. **348/150**; 348/143
(58) Field of Search 348/143–160

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,216,502 A * 6/1993 Katz 348/150
5,666,157 A * 9/1997 Aviv 348/150
5,884,042 A * 3/1999 Winter et al. 345/866
6,317,152 B1 * 11/2001 Hobson et al. 348/150

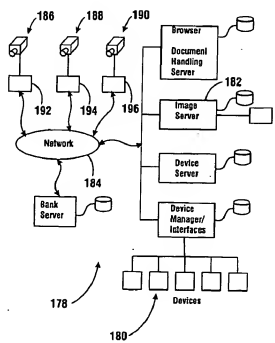
* cited by examiner

Primary Examiner—Andy Rao
(74) *Attorney, Agent, or Firm*—Ralph E. Jocke; Daniel D. Wasil; Walker & Jocke

(57) **ABSTRACT**

A system and method for capturing image data captures images responsive to programmed sequences. The sequences are performed on a periodic basis as well as in response to inputs corresponding to alarm conditions and transactions conducted at automated banking machines or other devices. Image data may also be captured in response to image conditions including the sensing of motion or the loss of usable video from selected cameras. Image data is stored in connection with data corresponding to circumstances associated with each triggering event. Stored image data may be searched by one or more parameters. Parameters include data stored in association with each image, types of events causing image data to be stored, as well as other image conditions in stored images.

70 Claims, 79 Drawing Sheets



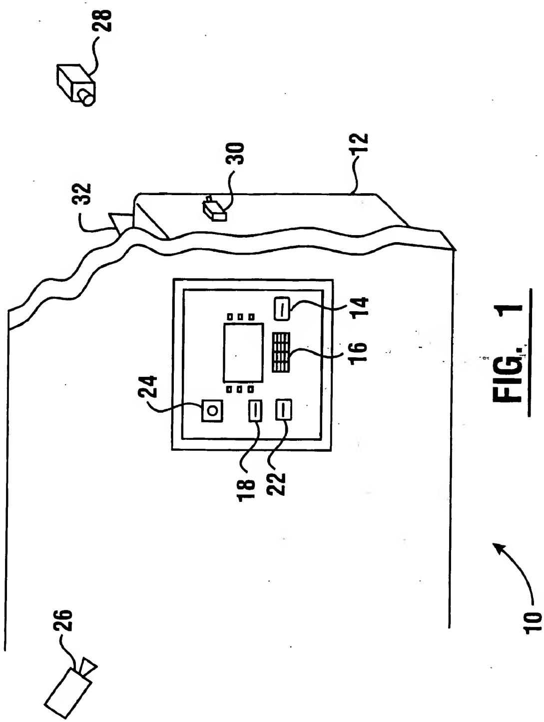
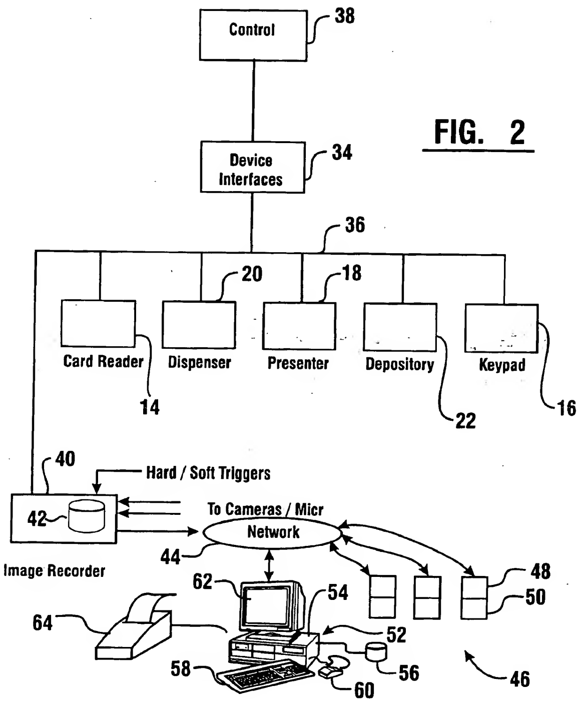


FIG. 1



Control
38
Device Interfaces
34
36
20
18
Card Reader
Dispenser
Presenter
Depository
Keypad
14
22
16
40
Hard / Soft Triggers
42
To Cameras / Micr
Network
44
Image Recorder
62
54
48
50
64
52
58
56
60
46

FIG. 2

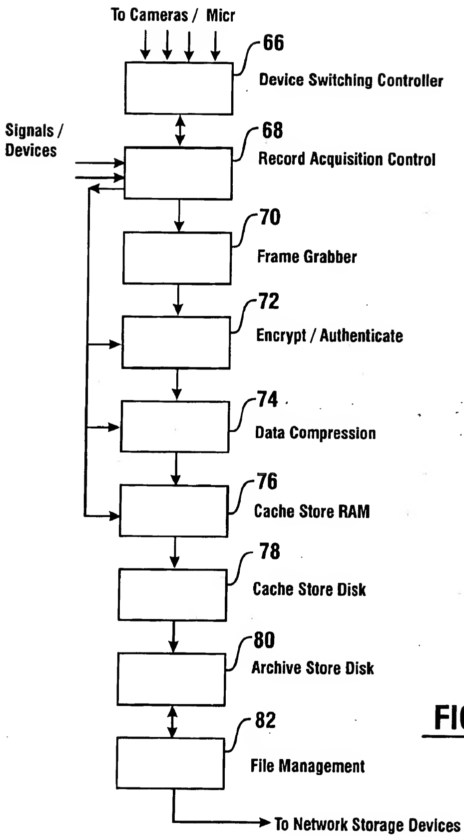

To Cameras / Micr
66
Device Switching Controller
Signals / Devices
68
Record Acquisition Control
70
Frame Grabber
72
Encrypt / Authenticate
74
Data Compression
76
Cache Store RAM
78
Cache Store Disk
80
Archive Store Disk
82
File Management
To Network Storage Devices

FIG. 3

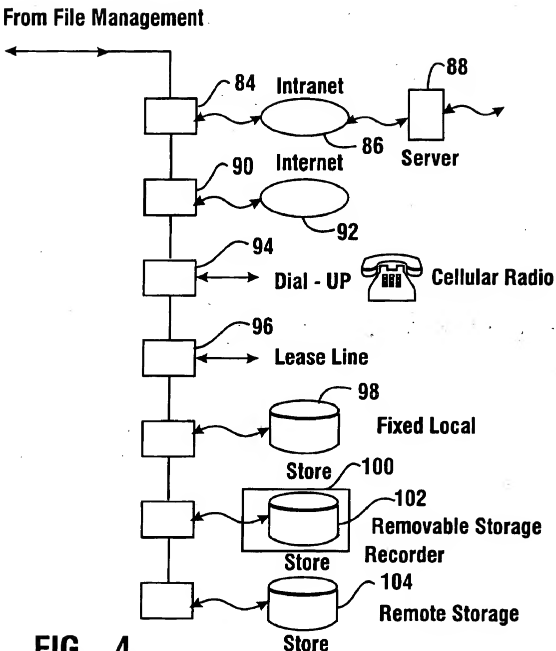

From File Management
84
Intranet
88
86
Server
90
Internet
92
94
Dial - UP
Cellular Radio
96
Lease Line
98
Fixed Local
Store
100
102
Removable Storage
Recorder
Store
104
Remote Storage
Store

FIG. 4

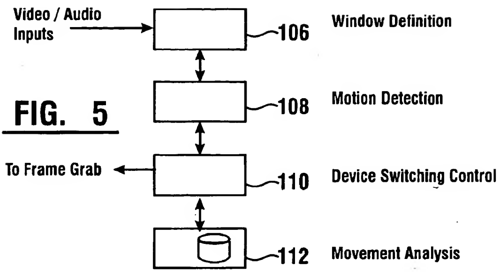


FIG. 5

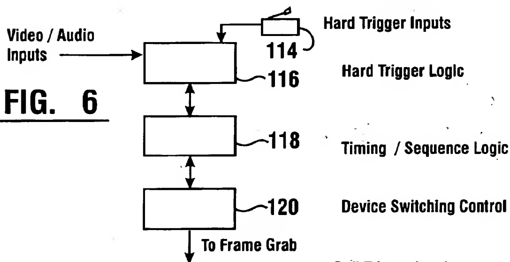


FIG. 6

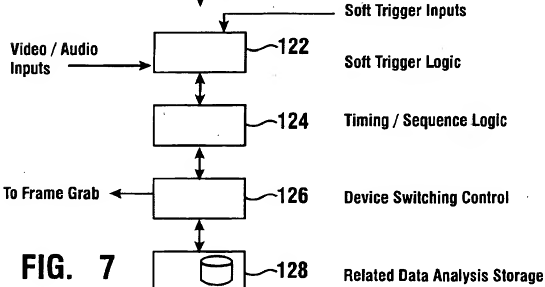


FIG. 7

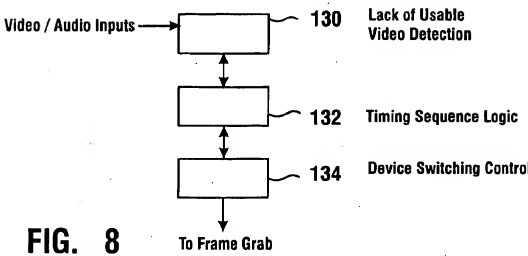

Video / Audio Inputs
130
Lack of Usable Video Detection
132
Timing Sequence Logic
134
Device Switching Control
To Frame Grab

FIG. 8

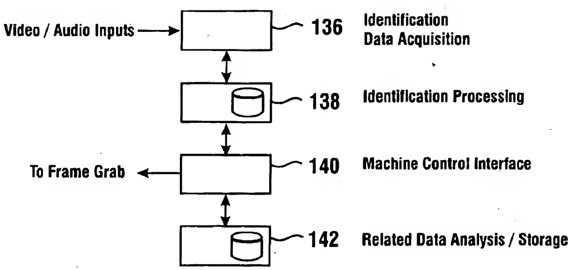

Video / Audio Inputs
136
Identification Data Acquisition
138
Identification Processing
To Frame Grab
140
Machine Control Interface
142
Related Data Analysis / Storage

FIG. 9

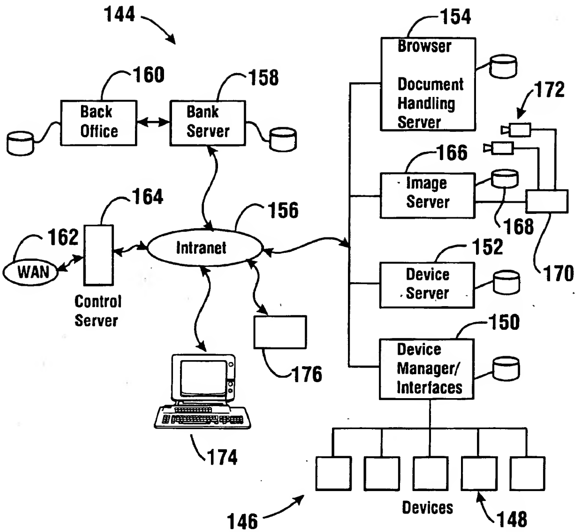

144
154
Browser
Document Handling Server
160
158
172
Back Office
Bank Server
166
Image Server
164
156
168
162
Intranet
152
WAN
Device Server
170
Control Server
150
Device Manager/ Interfaces
176
174
Devices
146
148

FIG. 10

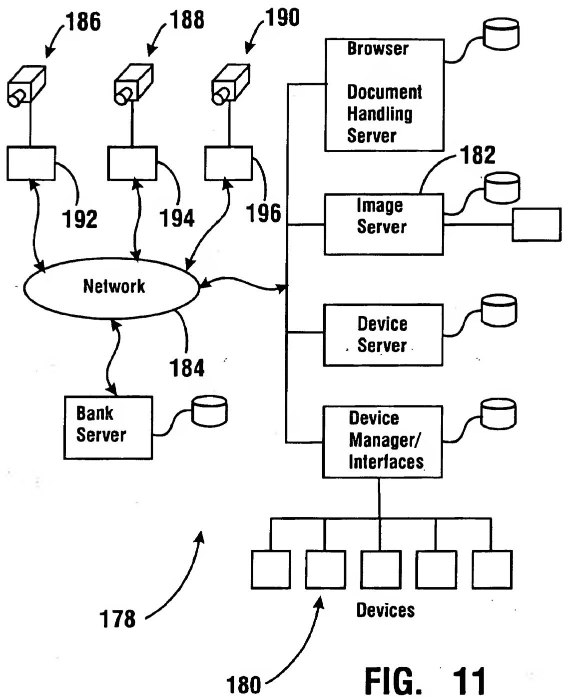

186
188
190
Browser
Document
Handling
Server
182
Image
Server
192
194
196
Network
184
Device
Server
Bank
Server
Device
Manager/
Interfaces
Devices
178
180

FIG. 11

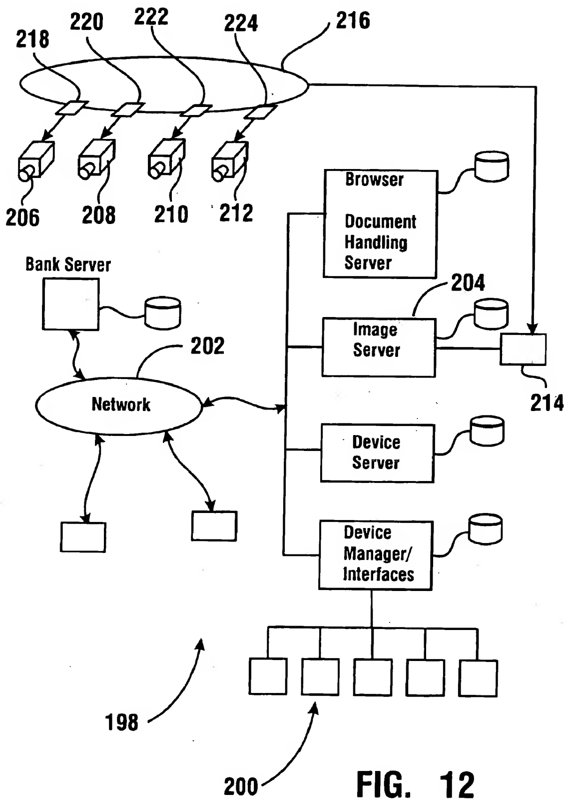

218
220
222
224
216
206
208
210
212
Browser
Document Handling Server
Bank Server
204
Image Server
202
Network
214
Device Server
Device Manager/ Interfaces
198
200

FIG. 12

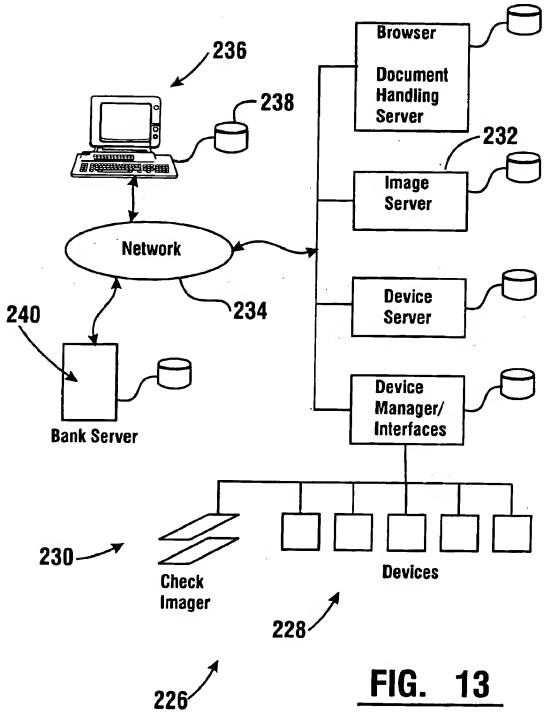

236
238
Browser
Document
Handling
Server
232
Image
Server
Network
234
240
Device
Server
Bank Server
Device
Manager/
Interfaces
230
Check
Imager
Devices
228
226

FIG. 13

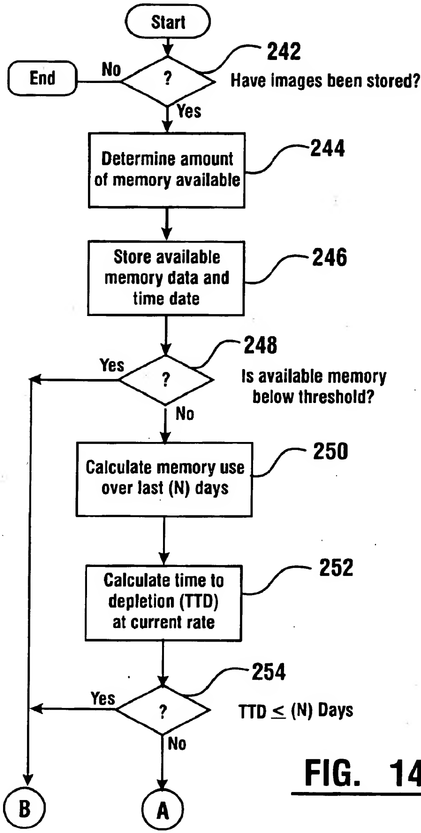

Start
?
242
Have images been stored?
No
End
Yes
Determine amount of memory available
244
Store available memory data and time date
246
?
248
Is available memory below threshold?
Yes
No
Calculate memory use over last (N) days
250
Calculate time to depletion (TTD) at current rate
252
?
254
TTD ≤ (N) Days
Yes
No
B
A

FIG. 14

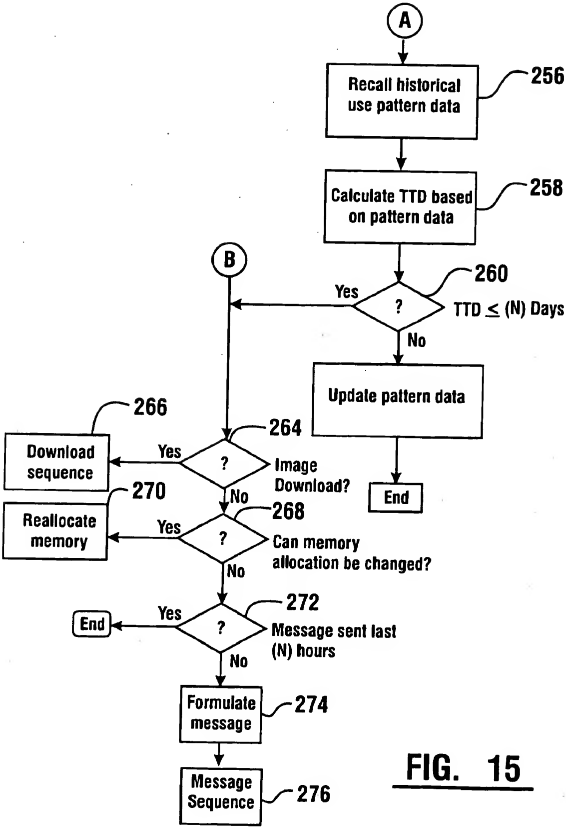

A
Recall historical use pattern data
256
Calculate TTD based on pattern data
258
B
Yes
?
260
TTD ≤ (N) Days
No
Update pattern data
End
266
Download sequence
Yes
264
?
Image Download?
No
270
Reallocate memory
Yes
268
?
Can memory allocation be changed?
No
End
Yes
272
?
Message sent last (N) hours
No
Formulate message
274
Message Sequence
276

FIG. 15

Menu Item	Description		Privileges	
		Admin.	Operator	Service
Image Search	Search for images stored on the hard disk drive of AccuTrack	✓	✓	—
View Log Files	View the system's log files for the diagnostics and log on activity	✓	✓	✓
Camera Setup	Set up custom names for the cameras that are easily identifiable.	✓	—	—
E-mail Setup	Set up e-mail addresses for use in sequences. During sequences, you can automatically send a system-written message to the appropriate personnel.	✓	—	—
User Access Setup	Add delete, and change user IDs, passwords and access rights	✓	—	—
ATM Setup	Set up the communications for any ATM connections.	✓	—	—
Sequence Setup	Set up sequences for the camera routines and for alarms	✓	—	—
Motion Setup	Define the areas for cameras that detect motion.	✓	—	—
Image Removal	Delete selected old images on AccuTrack to make room for new images.	✓	—	—
Diagnostics	Check systems diagnostics. Often used to trouble shoot the system.	✓	—	✓
Apply Changes	Apply all recent configuration changes made to the system. Note that during application of the changes, recording of images will be temporarily halted.	✓	—	✓
Help	Access to on-line help.	✓	✓	✓

FIG. 16

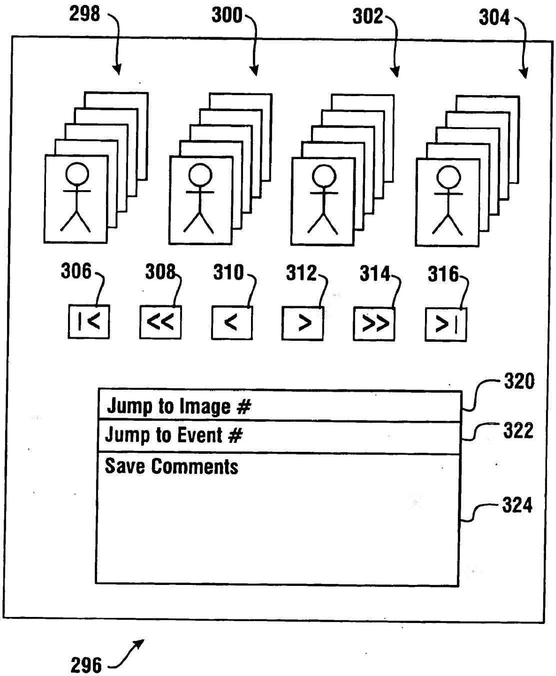

298
300
302
304
306
308
310
312
314
316
|<
<<
<
>
>>
>|
Jump to Image #
Jump to Event #
Save Comments
320
322
324
296

FIG. 17

Buttons	Description
|< >|	Use these button to go to the beginning or the end of a series of events or images (depending on the direction of the arrow).
<< >>	Use these buttons to go forward or backward by ten events or images (depending on the direction of the arrow).
< >	Use these buttons to go forward or backward by one event or image (depending on the direction of the arrow).
Jump to Image # Jump to Event #	Type the number of the image or events you want to view, and click on this button to display that image as the large image. The image or event number displays next to each thumbnail frame (for example, Image 7 of 48).
Save Comments	To store comments with the image, type your comments in the comments field, and click on this button. The next time this image is retrieved, the comments display with the image.

318

FIG. 18

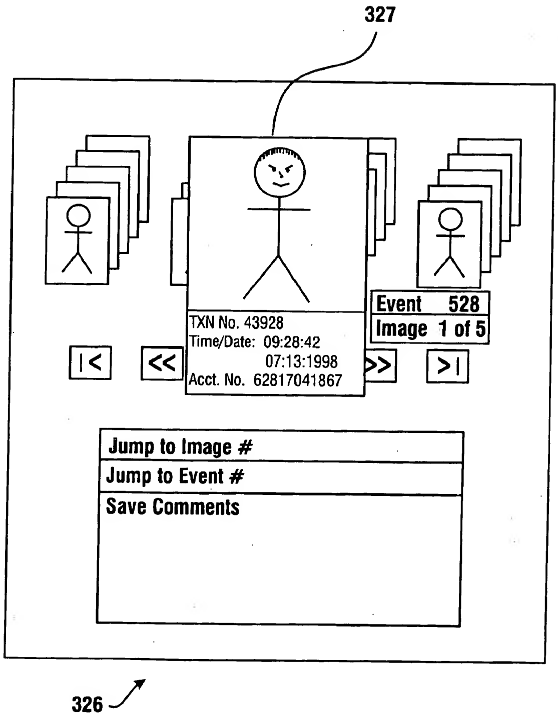

327
TXN No. 43928
Time/Date: 09:28:42
07:13:1998
Acct. No. 62817041867
Event 528
Image 1 of 5
|<
<<
>>
>|
Jump to Image #
Jump to Event #
Save Comments
326

FIG. 19

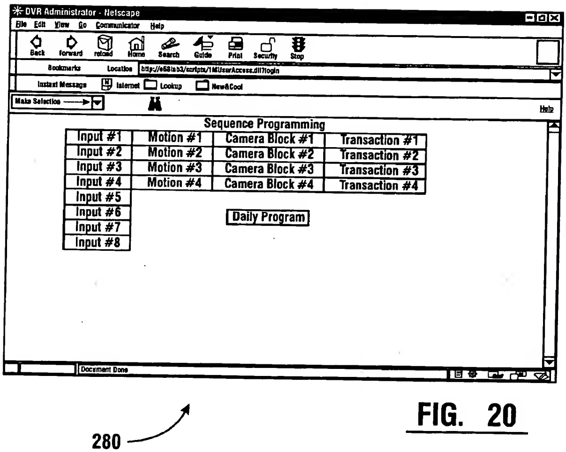
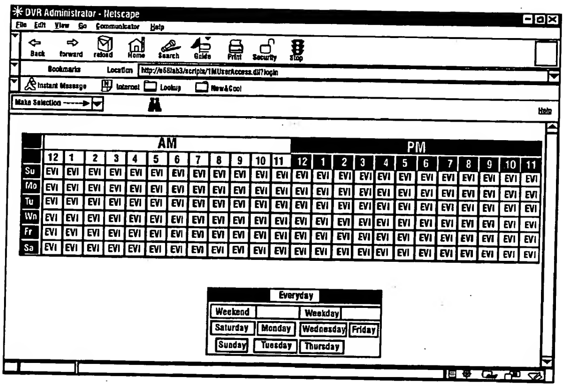
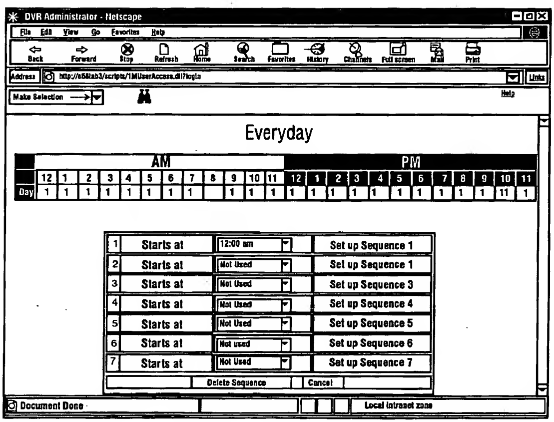

DVR Administrator - Netscape
File Edit View Go Communicator Help
Back Forward Reload Home Search Guide Print Security Stop
Bookmarks Location
Instant Message Internet Lookup New&Cool
Make Selection
Help
Sequence Programming
Input #1
Input #2
Input #3
Input #4
Input #5
Input #6
Input #7
Input #8
Motion #1
Motion #2
Motion #3
Motion #4
Camera Block #1
Camera Block #2
Camera Block #3
Camera Block #4
Transaction #1
Transaction #2
Transaction #3
Transaction #4
Daily Program
Document Done
280

FIG. 20


DVR Administrator - Netscape
File Edit View Go Communicator Help
Back
forward
reload
Home
Search
Guide
Print
Security
Stop
Bookmarks
Location
Instant Message
Internet
Lookup
New&Cool
Make Selection
Help
AM
PM
12 1 2 3 4 5 6 7 8 9 10 11
12 1 2 3 4 5 6 7 8 9 10 11
Su
Mo
Tu
Wn
Fr
Sa
EVI
Everyday
Weekend
Weekday
Saturday
Monday
Wednesday
Friday
Sunday
Tuesday
Thursday

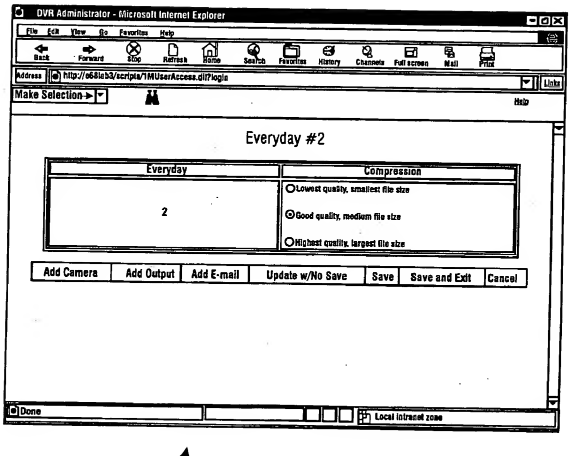
282

FIG. 21


DVR Administrator - Netscape
File Edit View Go Favorites Help
Back
Forward
Stop
Refresh
Home
Search
Favorites
History
Channels
Full screen
Mail
Print
Address
Links
Make Selection
Help
Everyday
AM
PM
Day
Starts at
12:00 am
Not Used
Set up Sequence 1
Set up Sequence 3
Set up Sequence 4
Set up Sequence 5
Set up Sequence 6
Set up Sequence 7
Delete Sequence
Cancel
Document Done
Local intranet zone

284

FIG. 22


DVR Administrator - Microsoft Internet Explorer
File Edit View Go Favorites Help
Back Forward Stop Refresh Home Search Favorites History Channels Full screen Mail Print
Address http://e68lab3/scripts/1MUserAccess.dll?login
Links
Make Selection
Help
Everyday #2
Everyday
Compression
2
Lowest quality, smallest file size
Good quality, medium file size
Highest quality, largest file size
Add Camera
Add Output
Add E-mail
Update w/No Save
Save
Save and Exit
Cancel
Done
Local intranet zone

286

FIG. 23

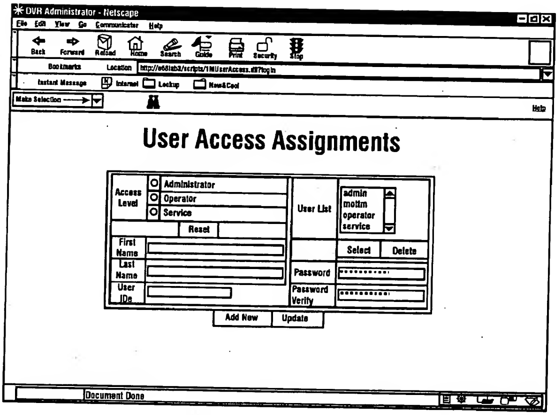
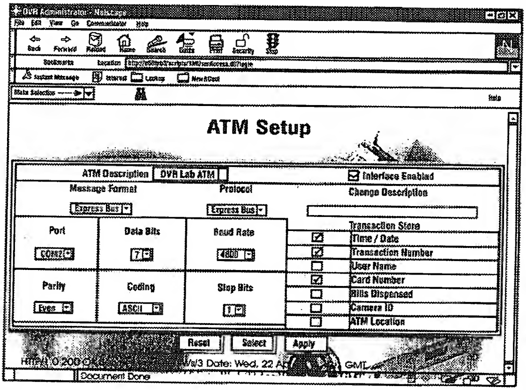

DVR Administrator - Netscape
File Edit View Go Communicator Help
Back Forward Reload Home Search Guide Print Security Stop
Bookmarks Location
Instant Message Internet Lookup New&Cool
Make Selection
Help
User Access Assignments
Access Level
Administrator
Operator
Service
Reset
First Name
Last Name
User IDs
User List
admin
mottm
operator
service
Select
Delete
Password
Password Verify
Add New
Update
Document Done

FIG. 24


ATM Setup
ATM Description
DVR Lab ATM
Interface Enabled
Message Format
Express Bus
Protocol
Express Bus
Change Description
Transaction Store
Port
COM2
Data Bits
7
Baud Rate
4800
Time / Date
Transaction Number
User Name
Card Number
Bills Dispensed
Camera ID
ATM Location
Parity
Even
Coding
ASCII
Stop Bits
1
Reset
Select
Apply
Document Done

288

FIG. 25

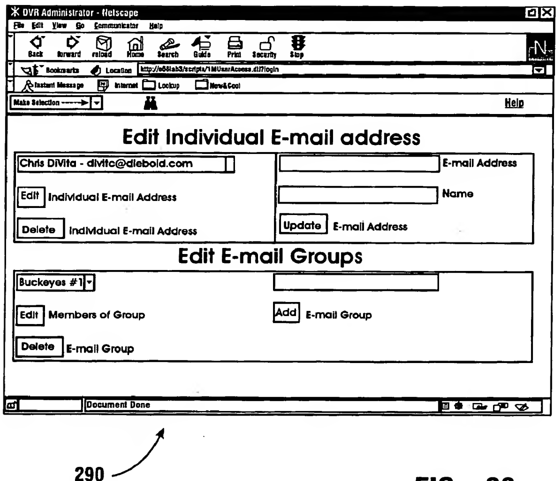

DVR Administrator - Netscape
File Edit View Go Communicator Help
Back Forward Reload Home Search Guide Print Security Stop
Bookmarks Location
Instant Message Internet Lookup New&Cool
Make Selection
Help
Edit Individual E-mail address
Chris DiVita - divitc@diebold.com
E-mail Address
Edit Individual E-mail Address
Name
Delete Individual E-mail Address
Update E-mail Address
Edit E-mail Groups
Buckeyes #1
Edit Members of Group
Add E-mail Group
Delete E-mail Group
Document Done
290

FIG. 26

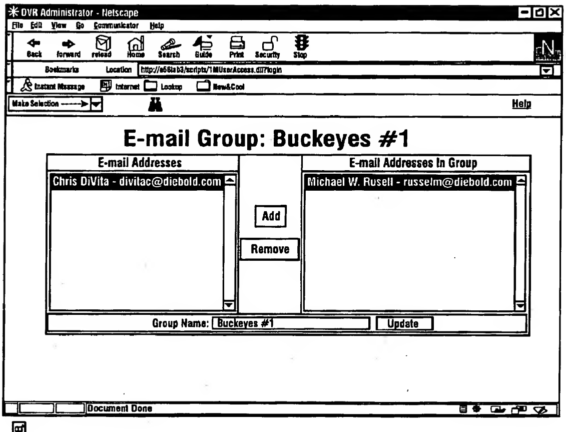

DVR Administrator - Netscape
File Edit View Go Communicator Help
Back forward reload Home Search Guide Print Security Stop
Bookmarks Location http://a56ab3/scripts/1MUserAccess.dll?login
Instant Message Internet Lookup New&Cool
Make Selection
Help
E-mail Group: Buckeyes #1
E-mail Addresses
Chris DiVita - divitac@diebold.com
E-mail Addresses In Group
Michael W. Rusell - russelm@diebold.com
Add
Remove
Group Name: Buckeyes #1
Update
Document Done

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FIG. 27

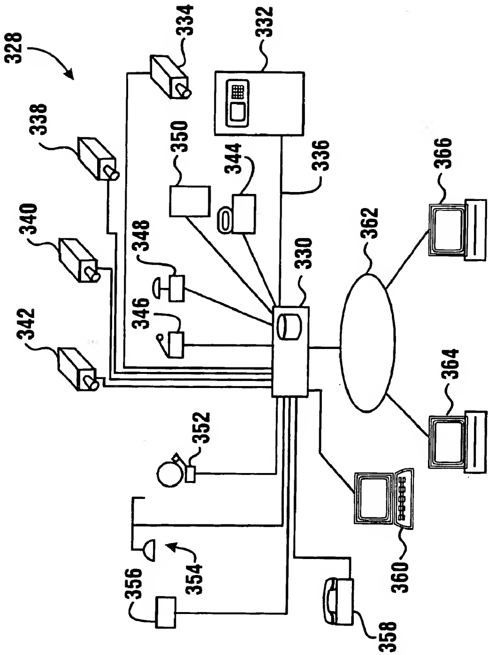

328
334
332
338
350
344
336
340
348
330
362
366
342
346
364
352
354
356
360
358

FIG. 28

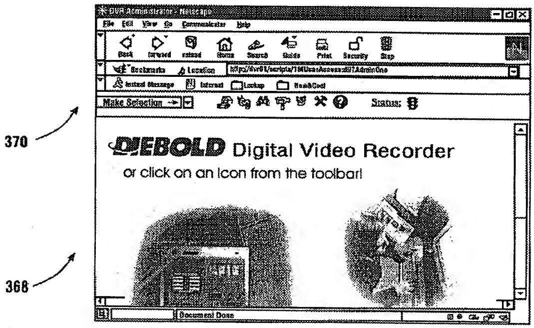
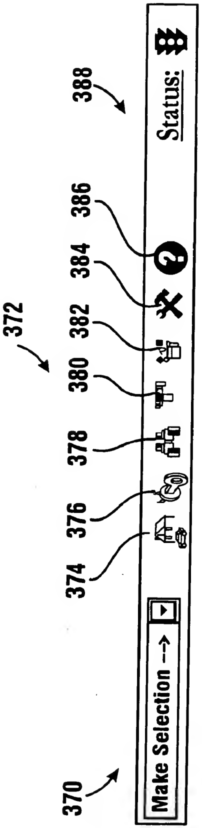

370
368
Make Selection
Status:
DIEBOLD Digital Video Recorder
or click on an Icon from the toolbar!
Document Done

FIG. 29



Toolbar (administrator access level)

FIG. 30

AccuTrack Toolbar Items

ITEM	NAME	COMMENTS
MENU BOX [1]		
Make Selection -->	Menu box with drco-down arrow	Click on the drop-down arrow for a list of main menue items. The access level of the user determines the displayed menus items.
MAIN MENU ICONS [1]		
 374	Home Icon	Click on the Home icon to go to the AccuTrack home page.
 376	Logoff Icon	Click on the Logoff Icon to log off the AccuTrack. The AccuTrack logon page re-displays.
 378	Perform Image Search Icon	Click on the Perform Image Search Icon (binoculars) to access the Image Search function.
 380	Camera Check Icon	Click on the Camera Check Icon to access the Camera Check function.
 382	System Configuration Icon	Click on the System Configuration Icon to display the DVR System Config submenu in a menu panel on the left side of the page.
 384	DVR System Tools Icon	Click on the Tools Icon to display the DVR Tools submenu in a menu panel on the left side of the page.
 386	Help Icon	CLick on the Help menu to display on-line help.

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FIG. 31

AccuTrack Toolbar Items (continued)

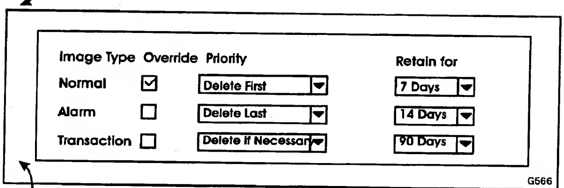
ITEM	NAME	COMMENTS
STATUS [2]		
Status: 388	Display status warning messages	Toggle (click once to turn off and click again to turn on) on the word Status to display status warning messages in a pop-up dialog box.
 390	Green light status icon	AccuTrack is capturing images properly.
 392	Thermometer status icon	AccuTrack is nearing maximum storage capacity and not storing images. The disk is full.
 394	Yellow hand (caution) status icon	AccuTrack is running with errors. Check the diagnostics log file for more information.
 396	Red diskette status icon	Pending changes have not been applied.
 398	Stop sign status icon	An application error has occurred. Check the diagnostics log file for more information. **NOTE** • This icon may display temporarily if you attempt to use AccuTrack while AccuTrack is applying changes. Wait a few moments and then try again. • If you are logged on from a remote PC, this icon may indicate a communications problem. AccuTrack may still be functioning correctly.

[1] Each main menu icon is represented by text in the drop-down menu. Click on a main menu icon or select from the drop-down menu to access the menu option.

[2] The current status icon displays each time you refresh your Web page or navigate to a new AccuTrack page. Sometimes AccuTrack updates the status while you remain on the same AccuTrack page.

FIG. 32

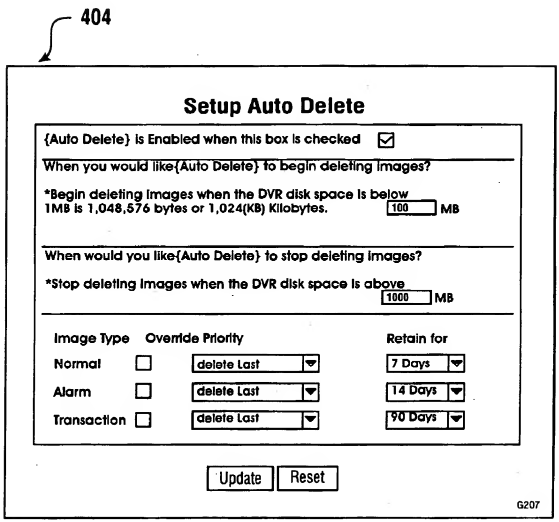
400



402

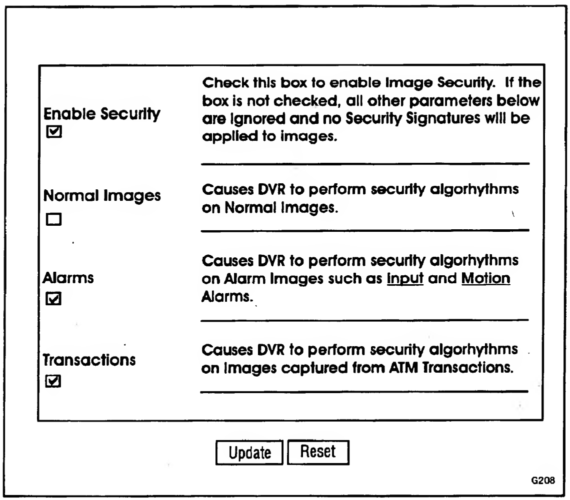
Example of Auto Delete Settings for Image Types

FIG. 33



Default Settings

FIG. 34


Enable Security
Check this box to enable Image Security. If the box is not checked, all other parameters below are ignored and no Security Signatures will be applied to images.
Normal Images
Causes DVR to perform security algorhythms on Normal Images.
Alarms
Causes DVR to perform security algorhythms on Alarm Images such as Input and Motion Alarms.
Transactions
Causes DVR to perform security algorhythms on Images captured from ATM Transactions.
Update
Reset
G208

406

FIG. 35

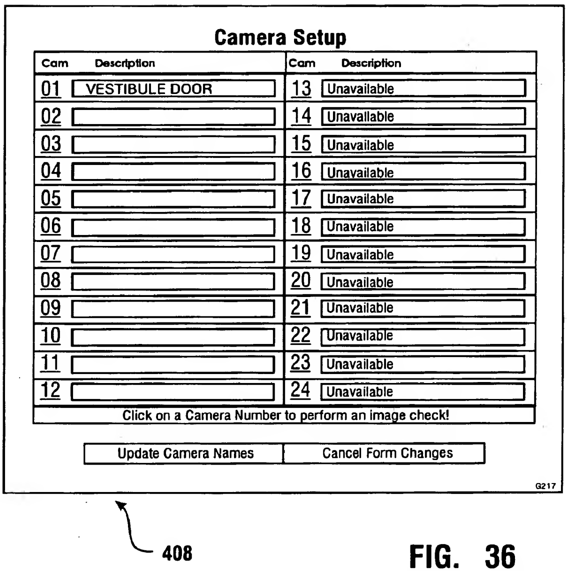
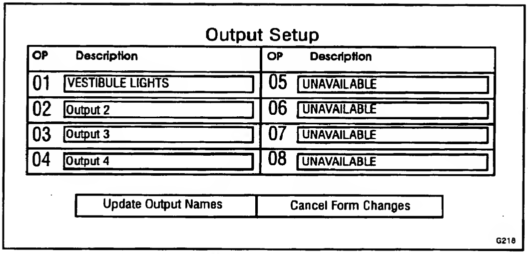

Camera Setup
Cam Description
Cam Description
01 VESTIBULE DOOR
02
03
04
05
06
07
08
09
10
11
12
13 Unavailable
14 Unavailable
15 Unavailable
16 Unavailable
17 Unavailable
18 Unavailable
19 Unavailable
20 Unavailable
21 Unavailable
22 Unavailable
23 Unavailable
24 Unavailable
Click on a Camera Number to perform an image check!
Update Camera Names
Cancel Form Changes
G217
408

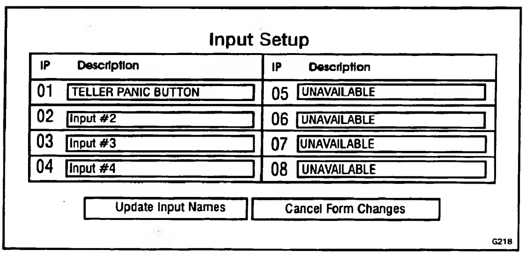
FIG. 36



410

Output Setup Page

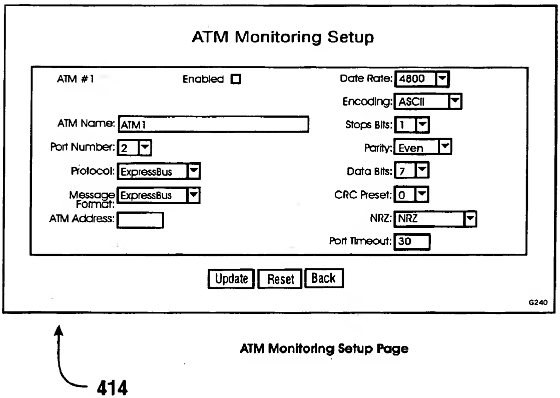
FIG. 37



412

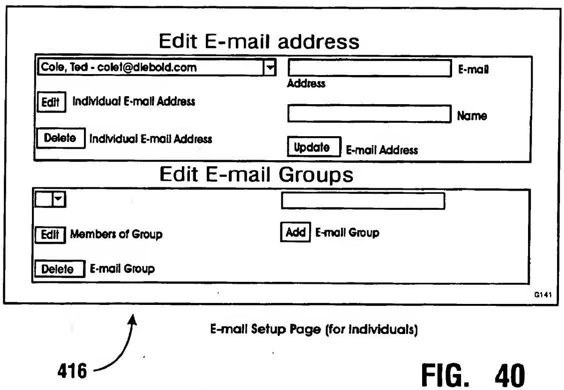
Input Setup Page

FIG. 38



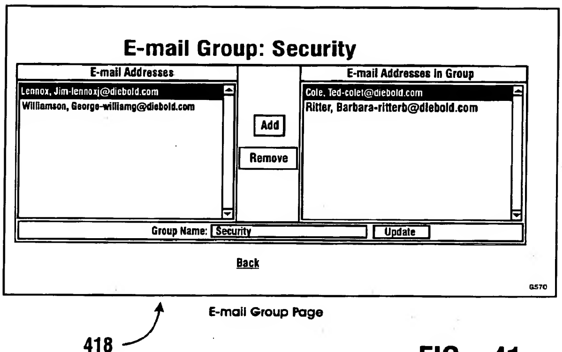
ATM Monitoring Setup Page

FIG. 39



E-mail Setup Page (for Individuals)

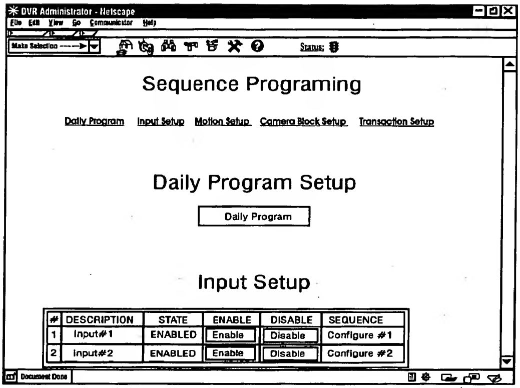
FIG. 40



E-mail Group Page

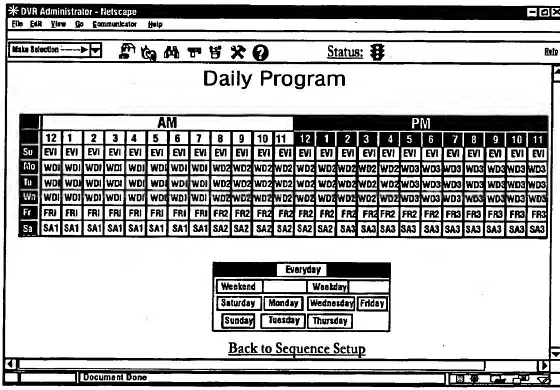
FIG. 41

420



Sequence Progamming Page

FIG. 42



422

Daily Program Page

FIG. 43

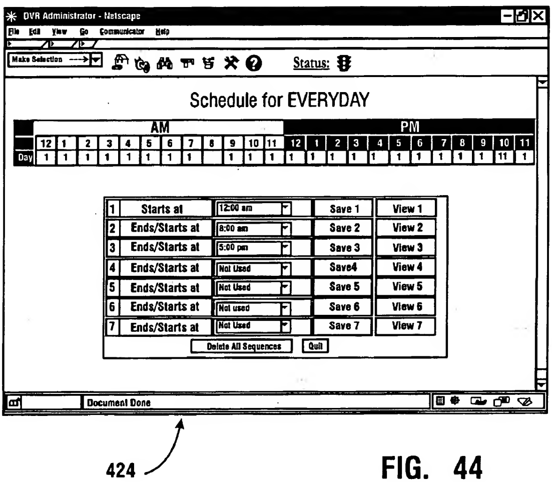
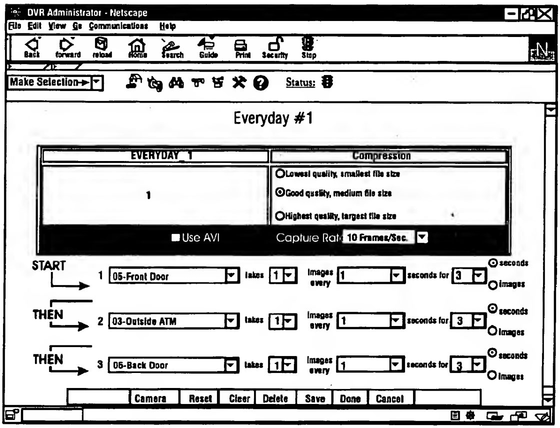

DVR Administrator - Netscape
File Edit View Go Communicator Help
Make Selection
Status:
Schedule for EVERYDAY
AM
PM
Day
1 Starts at 12:00 am Save 1 View 1
2 Ends/Starts at 8:00 am Save 2 View 2
3 Ends/Starts at 5:00 pm Save 3 View 3
4 Ends/Starts at Not Used Save4 View 4
5 Ends/Starts at Not Used Save 5 View 5
6 Ends/Starts at Not used Save 6 View 6
7 Ends/Starts at Not Used Save 7 View 7
Delete All Sequences
Quit
Document Done
424

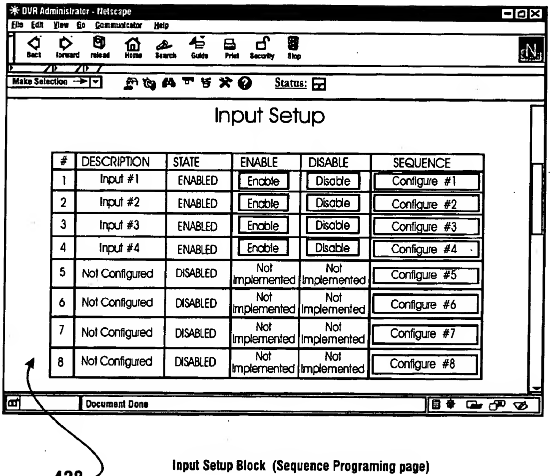
FIG. 44



426

Everyday #1 Page

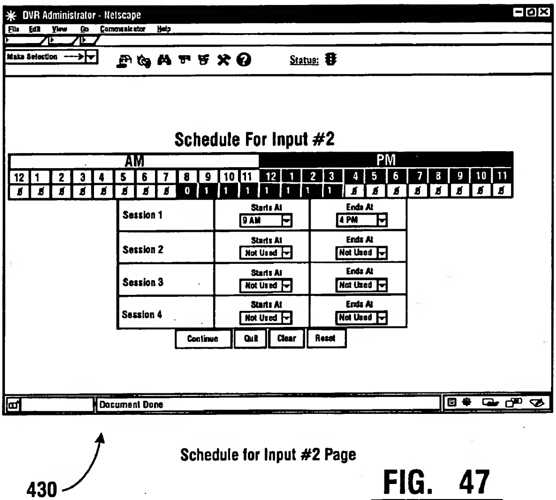
FIG. 45



428

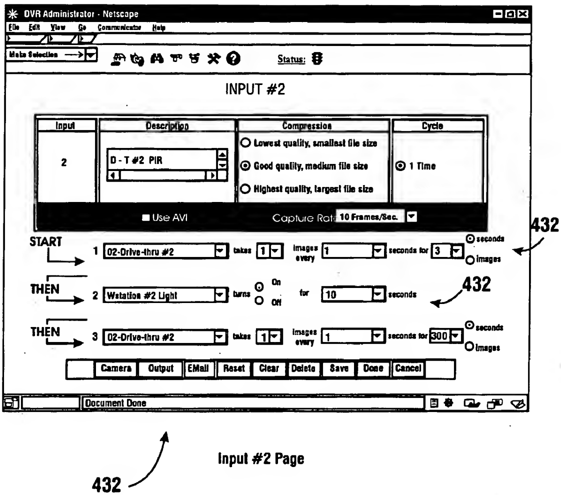
Input Setup Block (Sequence Programing page)

FIG. 46



Schedule for Input #2 Page

FIG. 47



Input #2 Page

FIG. 48

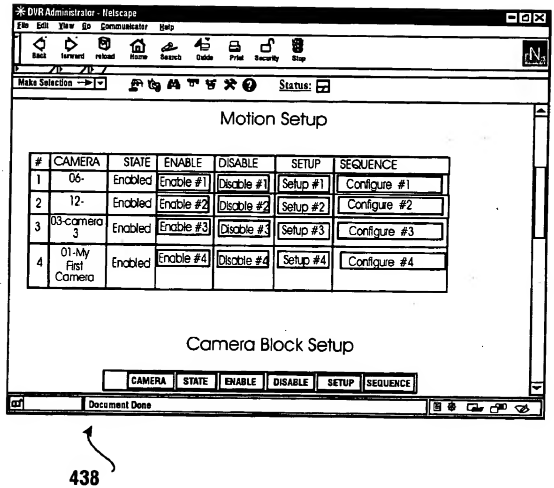
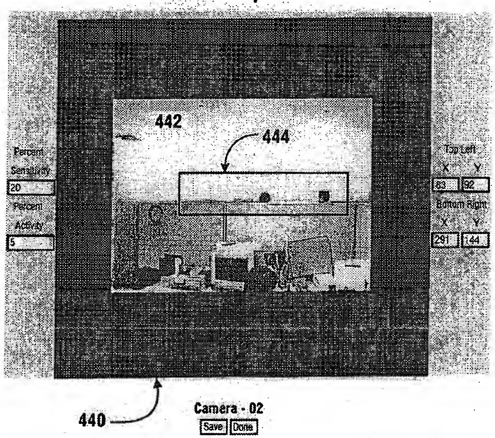

DVR Administrator - Netscape
File Edit View Go Communicator Help
Back Forward Reload Home Search Guide Print Security Stop
Make Selection
Status:
Motion Setup
| CAMERA | STATE | ENABLE | DISABLE | SETUP | SEQUENCE
1 | 06- | Enabled | Enable #1 | Disable #1 | Setup #1 | Configure #1
2 | 12- | Enabled | Enable #2 | Disable #2 | Setup #2 | Configure #2
3 | 03-camera 3 | Enabled | Enable #3 | Disable #3 | Setup #3 | Configure #3
4 | 01-My First Camera | Enabled | Enable #4 | Disable #4 | Setup #4 | Configure #4
Camera Block Setup
CAMERA STATE ENABLE DISABLE SETUP SEQUENCE
Document Done
438

FIG. 49

Motion Setup - 1



Motion Setup - 1 Page

FIG. 50

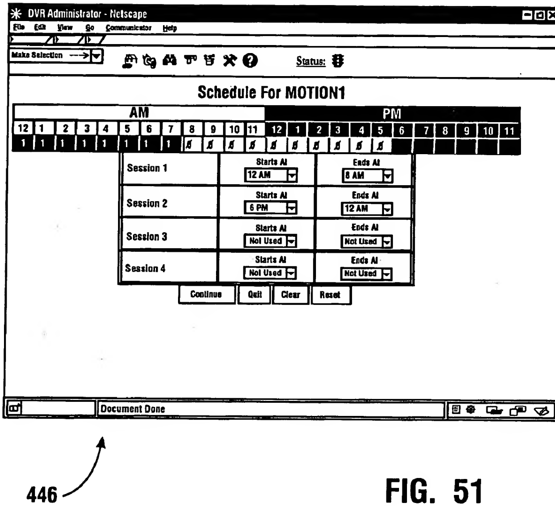
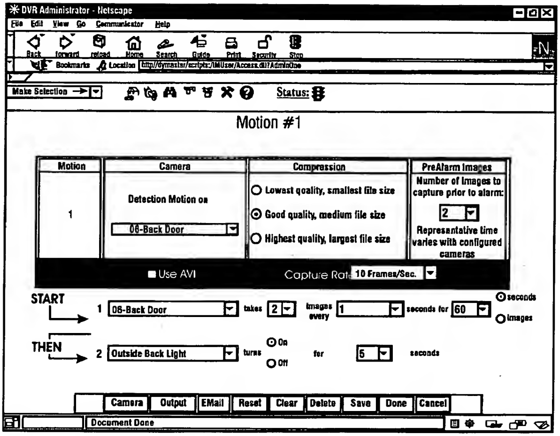

DVR Administrator - Netscape
File Edit View Go Communicator Help
Make Selection
Status:
Schedule For MOTION1
AM
PM
Session 1
Starts At
12 AM
Ends At
8 AM
Session 2
Starts At
6 PM
Ends At
12 AM
Session 3
Starts At
Not Used
Ends At
Not Used
Session 4
Starts At
Not Used
Ends At
Not Used
Continue
Quit
Clear
Reset
Document Done
446

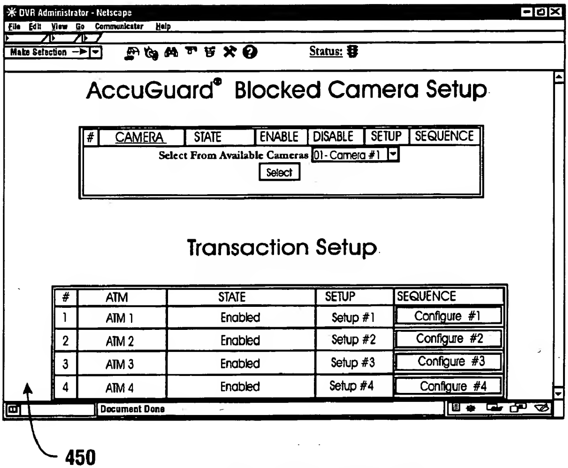
FIG. 51



448

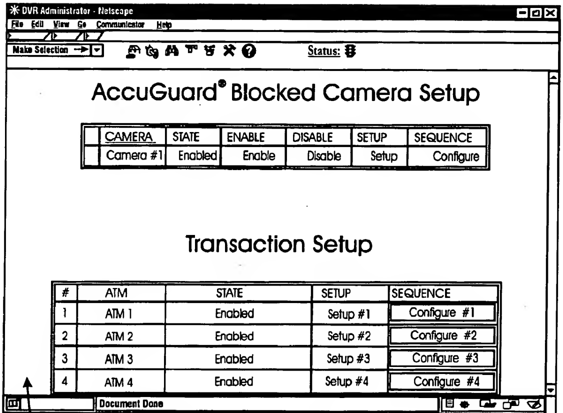
Motion #1 Page

FIG. 52



Before Selecting the Camera

FIG. 53



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After Selecting the Camera

FIG. 54

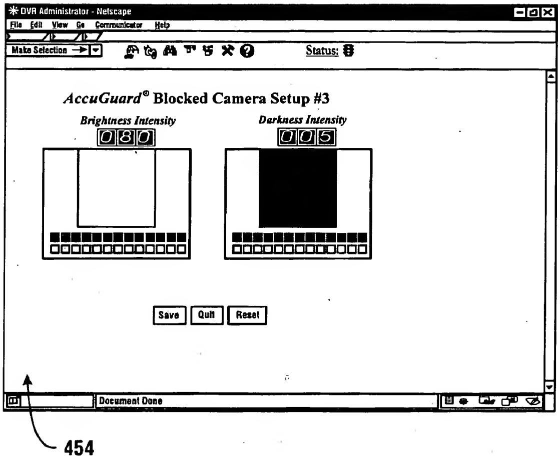

DVR Administrator - Netscape
File Edit View Go Communicator Help
Make Selection
Status:
AccuGuard® Blocked Camera Setup #3
Brightness Intensity
080
Darkness Intensity
005
Save
Quit
Reset
Document Done
454

FIG. 55

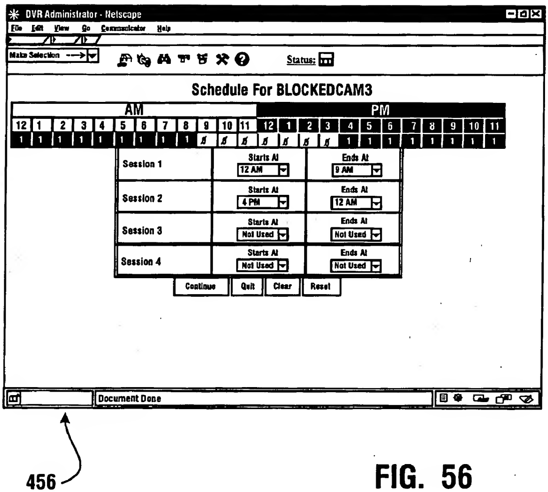
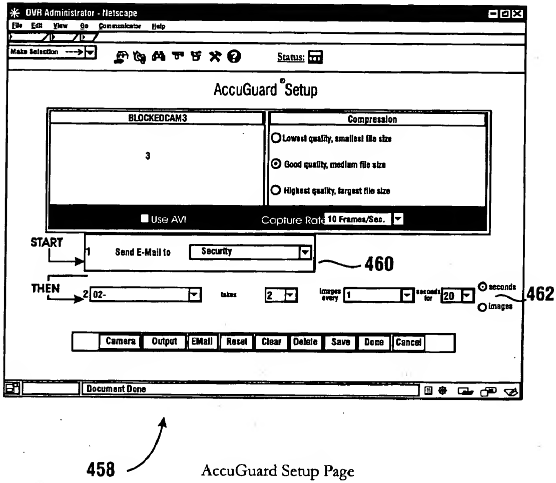
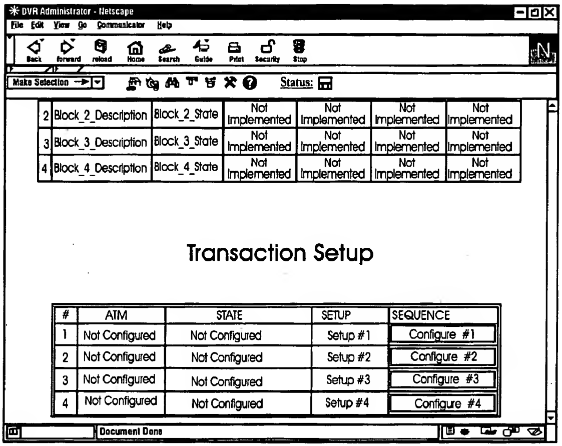

DVR Administrator - Netscape
File Edit View Go Communicator Help
Make Selection
Status:
Schedule For BLOCKEDCAM3
AM
PM
Session 1
Starts At
12 AM
Ends At
9 AM
Session 2
Starts At
4 PM
Ends At
12 AM
Session 3
Starts At
Not Used
Ends At
Not Used
Session 4
Starts At
Not Used
Ends At
Not Used
Continue
Quit
Clear
Reset
Document Done
456

FIG. 56



AccuGuard Setup Page

FIG. 57



464

Transaction Setup Block (Sequence Programming page)

FIG. 58

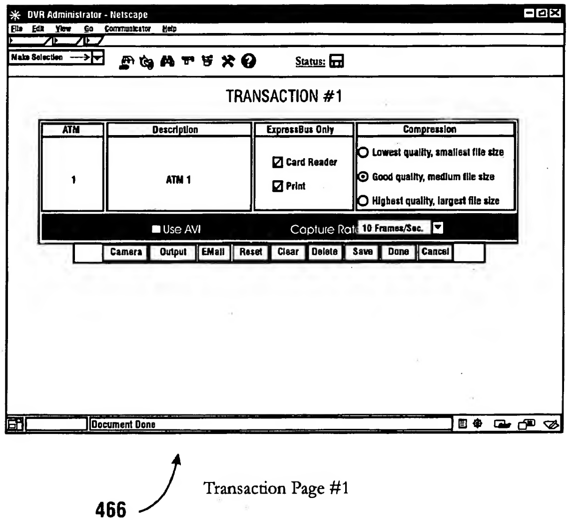

DVR Administrator - Netscape
File Edit View Go Communicator Help
Make Selection
Status:
TRANSACTION #1
ATM
Description
ExpressBus Only
Compression
1
ATM 1
Card Reader
Print
Lowest quality, smallest file size
Good quality, medium file size
Highest quality, largest file size
Use AVI
Capture Rate
10 Frames/Sec.
Camera
Output
EMail
Reset
Clear
Delete
Save
Done
Cancel
Document Done
466
Transaction Page #1

FIG. 59

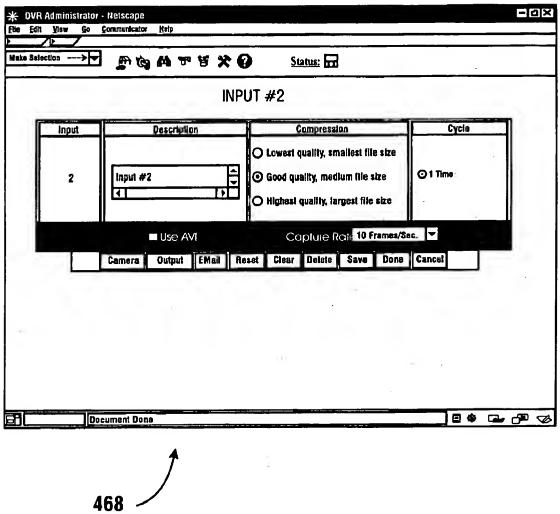

DVR Administrator - Netscape
File Edit View Go Communicator Help
Make Selection
Status:
INPUT #2
Input
Description
Compression
Cycle
2
Input #2
Lowest quality, smallest file size
Good quality, medium file size
Highest quality, largest file size
1 Time
Use AVI
Capture Rat
10 Frames/Sec.
Camera
Output
EMail
Reset
Clear
Delete
Save
Done
Cancel
Document Done
468

FIG. 60

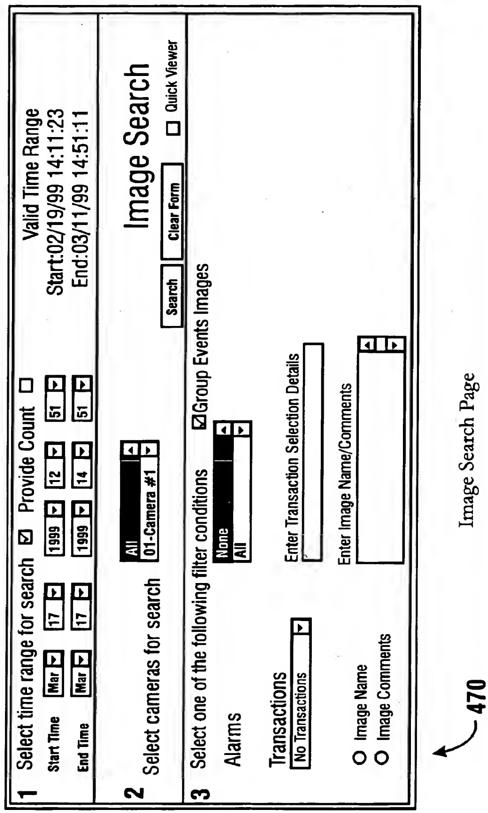
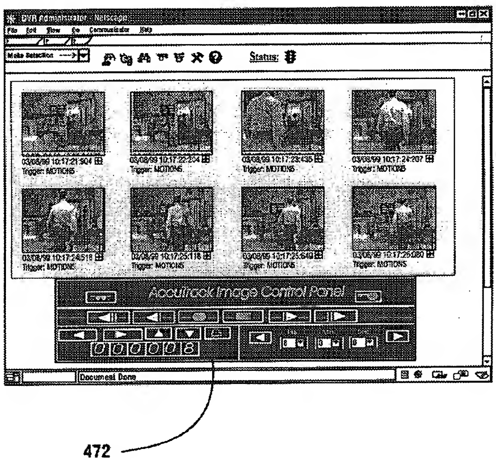


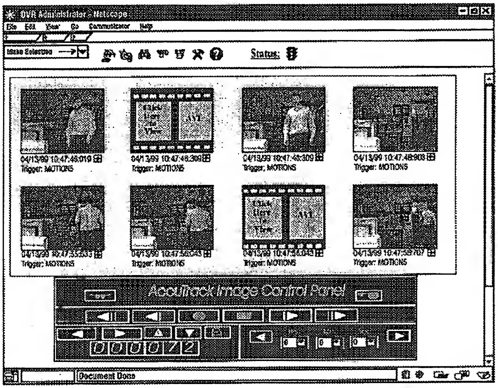
Image Search
1 Select time range for search ☑ Provide Count ☐
Valid Time Range
Start Time Mar 17 1999 12 51
End Time Mar 17 1999 14 51
Start:02/19/99 14:11:23
End:03/11/99 14:51:11
2 Select cameras for search
All
01-Camera #1
Search
Clear Form
☐ Quick Viewer
3 Select one of the following filter conditions
☑Group Events Images
Alarms
None
All
Transactions
No Transactions
Enter Transaction Selection Details
Image Name
Image Comments
Enter Image Name/Comments
470
Image Search Page

FIG. 61



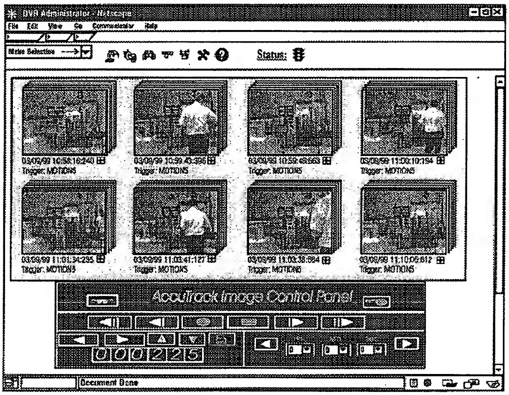
DVR Administrator - Netscape
Status:
03/08/99 10:17:21:904
Trigger: MOTIONS
03/08/99 10:17:22:204
Trigger: MOTIONS
03/08/99 10:17:23:435
Trigger: MOTIONS
03/08/99 10:17:24:207
Trigger: MOTIONS
03/08/99 10:17:24:518
Trigger: MOTIONS
03/08/99 10:17:25:118
Trigger: MOTIONS
03/08/99 10:17:25:649
Trigger: MOTIONS
03/08/99 10:17:26:080
Trigger: MOTIONS
AccuTrack Image Control Panel
000008
Document Done
472

FIG. 62



Images Page Including AVI Symbols for AVI Files

FIG. 63



Standard Events Page

FIG. 64

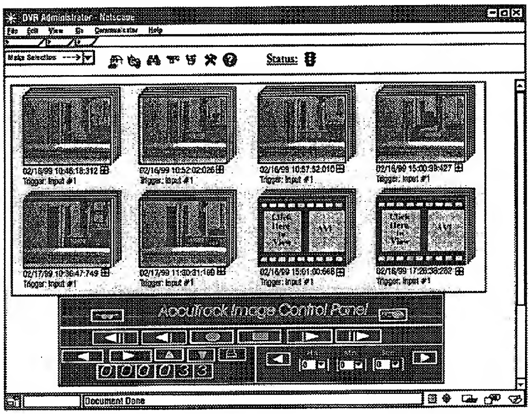

DVR Administrator - Netscape
Status:
02/16/99 10:46:18:312
Trigger: Input #1
02/16/99 10:52:02:026
Trigger: Input #1
02/16/99 10:57:52:010
Trigger: Input #1
02/16/99 15:00:38:427
Trigger: Input #1
02/17/99 10:36:47:749
Trigger: Input #1
02/17/99 11:30:31:189
Trigger: Input #1
02/16/99 15:01:00:666
Trigger: Input #1
02/16/99 17:28:38:282
Trigger: Input #1
AccuTrack Image Control Panel
000033
Document Done

FIG. 65

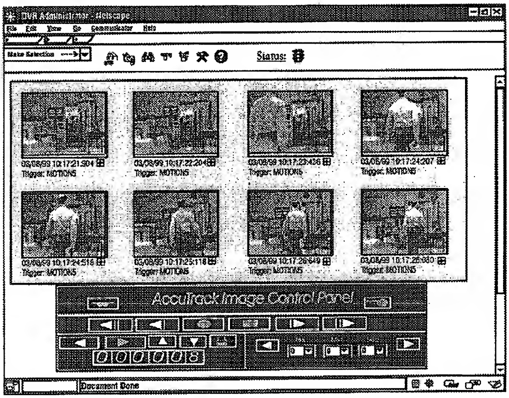
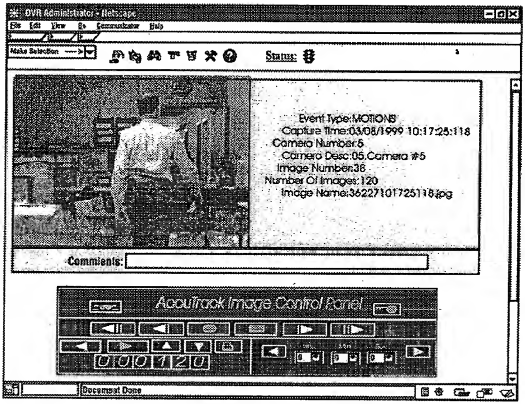

Status:
03/08/99 10:17:21.904
Trigger: MOTIONS
03/08/99 10:17:22.204
Trigger: MOTIONS
03/08/99 10:17:23.436
Trigger: MOTIONS
03/08/99 10:17:24.207
Trigger: MOTIONS
03/08/99 10:17:24.518
Trigger: MOTIONS
03/08/99 10:17:25.118
Trigger: MOTIONS
03/08/99 10:17:26.649
Trigger: MOTIONS
03/08/99 10:17:26.930
Trigger: MOTIONS
AccuTrack Image Control Panel
000008
Document Done

FIG. 66



Event Images Not Grouped

FIG. 67

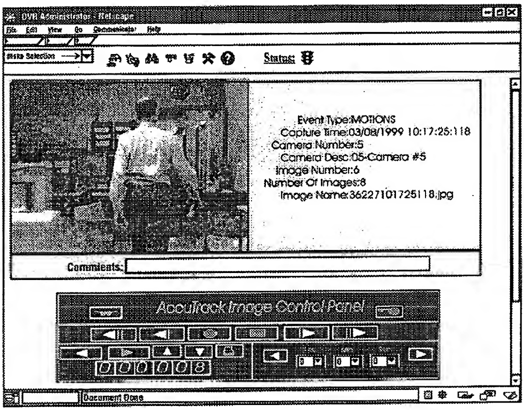

DVR Administrator - Netscape
File Edit View Go Communicator Help
Status:
Event Type:MOTIONS
Capture Time:03/08/1999 10:17:25:118
Camera Number:5
Camera Desc:05-Camera #5
Image Number:6
Number Of Images:8
Image Name:36227101725118.jpg
Comments:
AccuTrack Image Control Panel
Document Done

FIG. 68

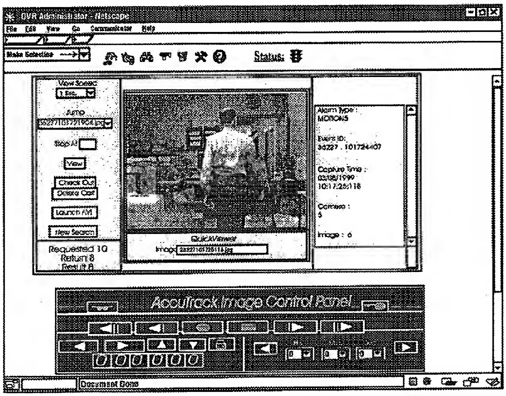

DVR Administrator - Netscape
File Edit View Go Communicator Help
Status:
View Speed
Jump
Stop At
View
Check Out
Delete Cart
Launch AVI
New Search
Requested 10
Return 8
Result 8
QuickViewer
Image
Alarm Type :
MOTIONS
Event ID:
Capture Time :
Camera :
Image : 6
AccuTrack Image Control Panel
Document Done

FIG. 69

Quick Viewer Page

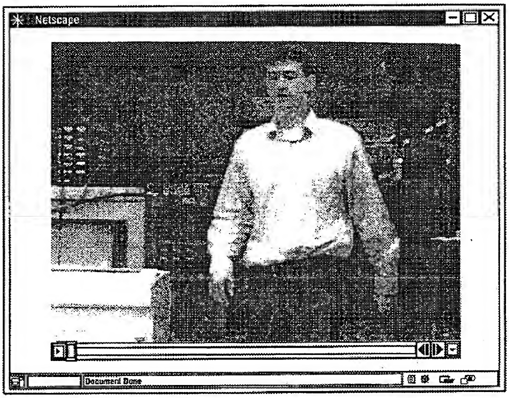


FIG. 70

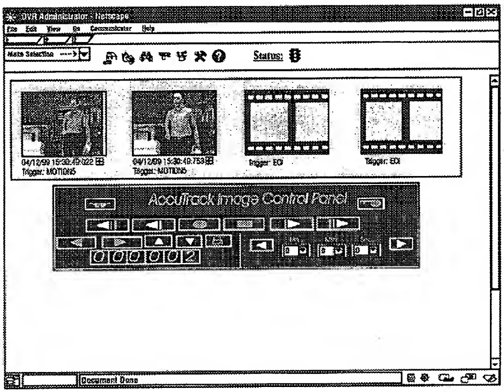

DVR Administrator - Netscape
File Edit View Go Communicator Help
Make Selection
Status:
04/12/99 15:30:49:022
Trigger: MOTION5
04/12/99 15:30:49:753
Trigger: MOTION5
Trigger: EOI
Trigger: EOI
AccuTrack Image Control Panel
Document Done

FIG. 71

Image Cart Page

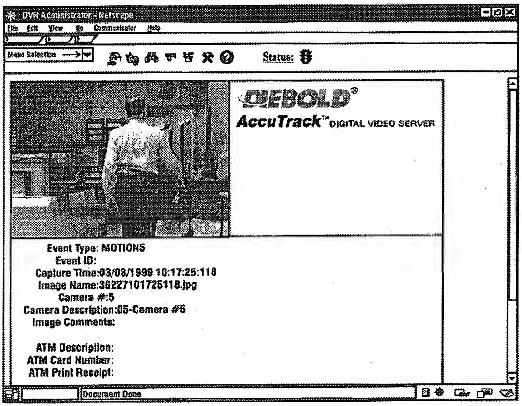


FIG. 72

Search Results Pages and Views

Page	Figure/View	Comments	Procedures
Images page (standard)	FIG 62	Note the followiog items. • This page displays up to eight single thumbnail images. • Images display with single black borders. • If you do not select Group Events images on the Image Search page or you do not modify the default filter conditions, the images on the first search results page that displays.	To display an enlarge single image, click on a thumbnail image displayed on the images page.
Images page for AVI mode	FIG 63	When a sequence is captured in AVI mode. Images are saved in the following format: • The first image is saved as a JPEG. file • All images between the first image and the last image are saved as an AVI clip. • The last image is saved as a JPEG file.	To view the AVI clip, click on the AVI symbol.
Events Page (standard)	FIG. 64	Note the following items: • This page displays up to eight events. • For each event, a thumbnail image of the first image in the event displays. • Images display with black feathered borders that suggest group images. • If you select Group Event Images on the Image Search page and modify the default filter conditions, the events page is the first search results page that displays. Otherwise, this page is not accessible.	To display the expanded view of a specific event, click on a thumbnail image displayed on the events page.
Events page including events captured in AVI mode	FIG. 65	Note the following items: • The AVI symbol indicates that AccuTrack captured en event in AVI mode. • If you anticipate that your search results include a lot of AVI files, it is preferable to de-select Group Event Images on the Images Search page. Then the JPEG files captured before and after the AVI clip display files on the first search results page (the Images page).	To view the AVI clip, click on the AVI symbol on the events page, and then click on the AVI symbol on the expanded event page.

FIG. 73

Search Results Pages and Views (continued)

Page	Figure/ View	Comments	Procedures
Expanded event page	FIG. 66	Expands an event group from the events page. Displays to eight thumbnail images for an event group selected on an events page.	To display an enlarge single image, click on a thumbnail image displayed on the expanded event page.
Single image page.	FIG. 67 FIG. 68	Displays a single enlarge image with information about the image.	Use the following options as desired. • Type comments in the Comments field that can be used as a filter condition in a subsequent image search. • Download the image cart from this page Print images from this page.
Quick Viewer page	FIG. 69	Note the buttons that are enabled on the AccuTrack Image Control Panel when Quick Viewer is selected on the Image Search page	To view the search results using Quick Viewer, use the AccuTrack Image Control Panel.
AVI viewer window	FIG. 70	You must have a Web browser plug-in such as QuickTime™ to view AVI clips. [2]	Use this window to view AVI files. Refer to specific documentation for your AVI viewer
Image cart page	FIG. 71	Note the following items: This page displays thumbnail images for JPG files in the image cart and AVI symbols for AVI files in the image cart. Images display with single red borders.	
Print preview page	FIG. 72	This page displays a print preview of a single image. The displayed information also prints with the image.	

[2] You can download QuickTime from http://www.apple.com/quicktime/.

FIG. 74

Data Stored or Displayed with an Enlarged Single Image

FIELD	DESCRIPTION
Event Type	Type of sequence that generated the image capture. May be one of the following types • SCHEDULED. Daily program sequences • INPUT. (Alarm) Input sequence • MOTION. Motion (detection) sequence • BLOCKEDCAM. Blocked camera sequence • CARD READ. Transaction sequence initiated by a card reader at the ATM • PRINTER. Transaction sequence initiated by printing of ATM receipt
Capture Time	Date and time the image was captured, to thousandths of a second
Image Name	Filename of the image on the AccuTrack hard disk
Camera #	Camera number (01 through 24)
Camera Description	Camera description entered under the Camera Setup menu option
Image Comments	Comments typed on a single menu page
Alarm Description	Alarm description entered under the Sequence Setup/input Setup menu option.
Number of Images	The Number of images is one of the following values: [1] • Number of images in the current cache of search results • Number of images in the search results • Number of images in the selected event
Image Number	Sequential number of images in the Number of images
ATM Description	ATM description entered under the ATM setup menu option.
ATM Card Number	ATM card number for the transaction
ATM Transaction Type	Description of the ATM activity, such as deposit, withdrawal, or card retained. This field may be unknown.
ATM Print Receipt	ATM receipt associated with the image. This option must be configured under the Sequence Setup/Transaction Setup menu option.

[1] On the single image page, the Number of images also displays on the image counter.

FIG. 75

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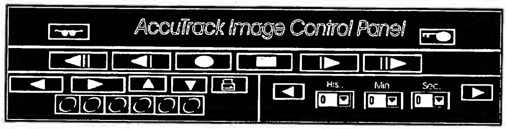


AccuTrack Image Control Panel

Buttons
Buttons on the AccuTrack Image Search Control Panel display with one of the following colors:

- **White** - Enabled
- **Yellow** - Enabled and selected. Click to activate.
- **Gray** - Disabled

FIG. 76

Image Counter

FIG. 77

AccuTrack Image Control Panel Buttons

BUTTONS	IMAGES PAGE	EVENTS PAGE	EXPANDED EVENT PAGE	SINGLE IMAGE PAGE	QUICK VIEWER PAGE
AccuTrack Image Control Panel					
476	View Images in the cart. (If there are no images in the cart, this button is disabled.)				
477	Save images in the image cart to disk with the a digital signature that authenticates the image and associated data. (If there are no images in the image cart, this button is disabled.)				
	Get first frame	Get first event	Get first frame in event	Get first frame	Get first frame in the group
	Get previous frame	Get previous event	Get previous frame in the event	Get previous frame	Get previous image in the group
	Clear image cart (if enabled)	Clear image cart (if enabled)	Clear image cart (if enabled)	Clear image cart (if enabled)	Play (view images in current group) [1]
	(disabled)	(disabled)	(disabled)	Save comments	Stop
	Get next frame	Get next event	Get next frame in the event	Get next event	Get next image in the group
	Get last frame	Get last event	Get last frame in the event	Get last event	Get last image in the group

FIG. 78

AccuTrack Image Control Panel Buttons (continued)

BUTTONS	IMAGES PAGE	EVENTS PAGE	EXPANDED EVENTS PAGE	SINGLE IMAGE PAGE	QUICK VIEWER PAGE
					
	Get previous set of 8 frames	Get previous set of 8 events	Get previous set of 8 frames in the event	Show events (if enabled)	Reverse frames
	Get next set of 8 frames	Get next set of 8 events	Get next set of 8 frames in the even	Show ATM visit (if enabled)	Forward frames
	View event images (first frame)	(disabled)	Return to events (up one level)	Return to the previous level	Get previous group
	Perform a new search	Perform a new search	Perform a new search	Check in or check out an image (toggle button) for the image cart	Get nextgroup
	Disabled	Disabled	Disabled	Print preview	Disabled
Image Counter (when Provide Count is selected and default filter conditions are modified on the Image Search page)	Displays the number of images that meet the search criteria	Displays the number of events that meet the search criteria	Displays the number of images in the event	Displays the number of images from the previous level (images page or expanded event page)	Displays the number of the current images in the current group
Image Counter (when Provide Count is not selected on the Image Search page)	Displays the number of images in the current cache [2]	Displays the number of events in the current cache [2]	Displays the number of images in the event	Displays the number of images from the previous level (images page or expanded event page)	Displays the number of the current images in the current group

FIG. 79

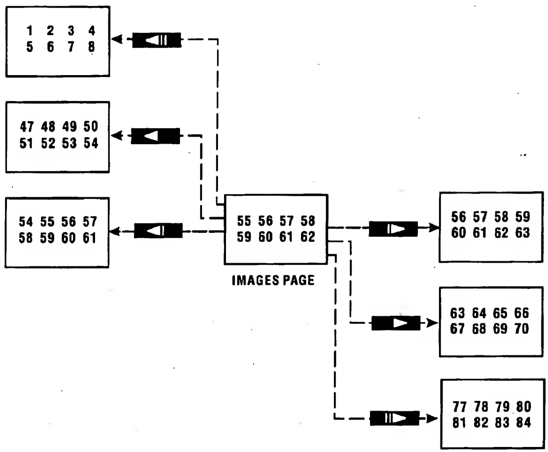
AccuTrack Image Control Panel Buttons (continued)

BUTTON	IMAGES PAGE	EVENTS PAGE	EXPANDED EVENT PAGE	SINGLE IMAGE PAGE	QUICK VIEWER PAGE
					
	Select hours, minutes, and seconds, and the then click on this button to go backward the selected amount of time.				
	Select hours, minutes, and seconds, and the then click on this button to go forward the selected amount of time.				

[1] To view an AVI clip from the Quick Viewer page, navigate to the AVI symbol and then click on the Launch AVI button.

[2] When you perform an image search, up to 100 images or events (as applicable) are cached to improve search results access times. When you do not select Provide Count on the Image Search page, the image counter displays information about the cached images or events.

FIG. 80



Note

- Rectangles represent the images pages.
- Numbers represent image numbers for the thumbnail images on the Images page.
- The example shows a total of 84 images in the search results.

FIG. 81

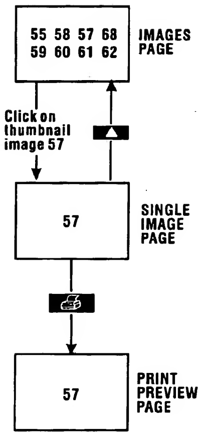


FIG. 82

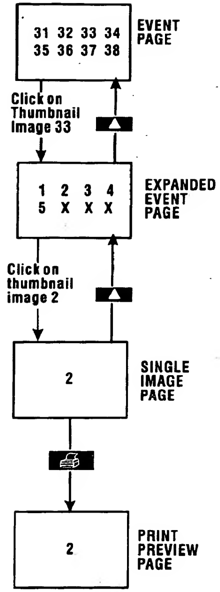


FIG. 83

Note
Rectangles represent search results pages.
Numbers represent event numbers or image numbers.
The example shows 5 images in event number 33.

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Image Cart Symbol

SYMBOL	IMAGES PAGE	EVENTS PAGE	EXPANDED EVENT PAGE	SINGLE IMAGE PAGE	SINGLE CART PAGE
Black image cart symbol	Image is not in the image cart. Click on the black image cart symbol to check out the image (add the image to the image cart).	Click on the black image cart symbol to check out all the images in the event (add the images to the image cart). [1]	Image is not in the image cart. Click on the black image cart symbol to check out the image (add the image to the image cart).	..[2]	Image is not in the image cart. [3] Click on the black image cart symbol to check out the image (add the image to the image cart).
Red image cart symbol	Image is in the image cart. Click on the red image cart symbol to check in the image (remove the image from the image cart).	(does not display)	Image is in the image cart. Click on the red image cart symbol to check in the image (remove the image from the image cart).	..[2]	Image is in the image cart. [3] Click on the red image cart symbol to check in the image (remove the image from the image cart).

[1] On the events page, the color on the image cart symbol is not significant.

[2] The image cart symbol does not display on the single image page. If the image is in the image cart, Image Checked Out displays in red italics with the displayed data.

[3] On the image cart page, all images initially display with the red image cart symbols. If you click on a red image cart symbol on the image cart page, the symbol changes to black and the image is removed from the image cart. The image continues to display on the image cart page until you re-access the page.

FIG. 84

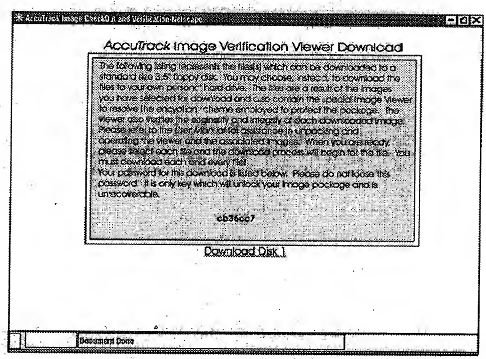
AccuTrack Image Verification Viewer Download
The following listing represents the file(s) which can be downloaded to a standard size 3.5" floppy disk. You may choose, instead, to download the files to your own personal hard drive. The files are a result of the images you have selected for download and also contain the special Image Viewer to resolve the encryption scheme employed to protect the package. The viewer also verifies the originality and integrity of each downloaded image. Please refer to the User Manual for assistance in unpacking and operating the viewer and the associated images. When you are ready, please select each file and the download process will begin for this file. You must download each and every file!
Your password for this download is listed below. Please do not loose this password. It is only key which will unlock your image package and is unrecoverable.
cb36cc7
Download Disk 1
Document Done

FIG. 85

SYSTEM AND METHOD FOR CAPTURING AND SEARCHING IMAGE DATA ASSOCIATED WITH TRANSACTIONS

This application claims the benefit of U.S. Provisional Application No. 60/103,731 filed Oct. 9, 1998.

TECHNICAL FIELD

This invention relates to transaction record systems. Specifically this invention relates to a transaction record system for an automated banking machine which provides image records as well as data records related to transactions and other activities. The invention further relates to a system which captures images and enables images and data to be stored, remotely accessed and selectively processed and analyzed.

BACKGROUND ART

Automated banking machines are known in the prior art. A common type of automated banking machine used by consumers is an automated teller machine ("ATM"). ATMs enable customers to carry out banking transactions such as dispensing cash, making deposits, making transfers of funds, depositing checks and other instruments, payment of bills and account balance inquiries. Other types of automated banking machines are used for purposes of dispensing tickets, scrip, travelers checks, airline tickets, gaming materials and other items of value. Other types of automated banking machines are used by service providers such as cashiers or bank tellers for purposes of dispensing or receiving currency, counting currency and determining the genuineness of currency. For purposes of this disclosure an automated banking machine will be considered as being any machine which accomplishes the handling or transfer of items having or representative of value.

In the past some automated banking machines have included a camera system. Cameras have been installed adjacent to the machine for purposes of viewing persons conducting transactions. Such cameras have been connected to video tape recorders and record an image of the customer conducting the transaction. Such systems have limitations because the tapes used to record the images must be periodically changed. A failure to change the tape could result in images no longer being recorded. Changing the tape too soon results in a waste of available image storage space. Tapes that are reused wear out after a few cycles.

A further drawback associated with tape recording systems used in connection with automated banking machines is that the tapes should be maintained for a substantial period. For example if a customer claims that they did not conduct a transaction, this will likely not be known until several weeks or months after the transaction was conducted. To determine if the customer's assertions are true the tape must be located. This involves cataloguing and storing tapes, often for extended periods of time. This is inconvenient and costly.

A further drawback associated with conventional image recording systems associated with automated banking machines is that the camera may be blocked. Such blocking may be deliberate or inadvertent. For example a criminal wishing to avoid identification may cover the lens area of the camera so that no usable video is obtained. Alternatively, lighting conditions such as sun glare and shadows may render a camera unable to provide a suitable video image.

A further limitation of existing ATM camera systems is that they often record only a single image during the

transaction. If that image happens to coincide with a time when the customer is not facing in a direction which enables the camera can take a suitable picture, the image is of no value. Alternatively, if a camera is operated to record throughout every transaction the available tape supply will be used up more quickly. In such situations the tape supply is often consumed by recording images of persons withdrawing very small amounts from the ATM.

A further issue that sometimes arises with regard to automated banking machines is shortages of materials or cash. Sometimes for example, the amount of cash remaining within a machine is less than available records suggest should be held therein. Similar issues may arise with other items that are dispensed from or deposited in automated banking machines. Such issues call into question whether there has been a machine malfunction, conversion by a person authorized to service the machine or theft by a third party. As servicers such as bank employees accessing automated banking machines are often unsupervised, it is sometimes impossible to determine the cause of the shortage.

Circumstances sometimes arise in the course of transactions at automated banking machines where it would be desirable to inform particular individuals of the existence of the circumstances. Such circumstances may include for example that the recording media being used to record images needs to be changed. Other conditions may include that someone has gained access to the machine or an area surrounding the machine. It would be desirable to include an image with or as part of some messages. Such information would enable persons who need to know about such conditions to take immediate action.

Certain types of automated banking machines also accept documents representative of value such as checks and travelers checks. Often issues arise concerning the authenticity of such items. Determining the authenticity of such items may be a time consuming process due to the need to physically retrieve such items and to compare indicia thereon to a genuine item. An example would be signature comparisons for determining whether a particular signature is appropriate. Such activities can be costly and time consuming.

There further exists a need for systems that operate so that when a triggering event occurs, the capture of images and other actions occur in a predetermined sequence. For example the occurrence of an image condition such that motion is sensed by a camera or that the camera is blocked, may cause additional images to be captured from the same or other cameras. In such circumstances images taken prior to the triggering event may be stored in correlated relation with the images corresponding to the event for a later analysis. In some circumstances it may be desirable to have images captured at different rates based on the nature of the triggering events, including at rates which comprise generally continuous image video capture. There further exists a need for systems in which a triggering event may consist of a change within a particular detection area, which is a subset of an entire image being viewed by a camera. This enables actions to be taken in response to changes in the detection area while other changes within the field of view may be ignored. There further exists a need to program an image capture system with such sequences in a simplified manner.

There further exists a need for systems in which captured images can be stored and analyzed. This may include for example analysis by the type of triggering event which caused the image to be captured. Other parameters for searching images would also be desirable to use, such as the

content of the image, the type of transaction with which it is associated or the time frame within which the image was captured. The ability to search such images by one or more of these parameters would greatly reduce the time necessary to locate desired images. In addition there exists a need for the selective deletion of images when available storage space approaches depletion. Such selective deletion may include eliminating image data associated with certain types of image events while selectively retaining other information.

There further exists a need for a system which can provide increased assurance of the authenticity and unaltered condition of an image. In some circumstances there may be concern that a captured image has been altered so that it is different from its original form. The ability to document that images are unaltered despite transfer from an image capture system to another system increases the evidentiary value of the captured image.

There further exists a need for an image capture system that can be used in connection with automated transaction machines as well as in other transaction or service environments. Such a system may record activities and transactions occurring within facilities at particular times to enable documentation of events that occur.

Thus there exists a need for a transaction record system which includes image capture capabilities that overcome the limitations associated with existing systems.

DISCLOSURE OF INVENTION

It is an object of the present invention to provide a transaction record system for an automated banking machine.

It is a further object of the present invention to provide a system for recording image data related to transactions conducted at an automated banking machine.

It is a further object of the present invention to provide a system for recording image and transaction data related to transactions conducted at an automated banking machine.

It is a further object of the present invention to provide a system for enabling access to image and transaction data related to transactions conducted at an automated banking machine remotely through a network.

It is a further object of the present invention to provide a system for accessing image and transaction data in response to events that occur at an automated banking machine.

It is a further object of the present invention to provide a system for obtaining image data and for taking actions in an appropriate programmed sequence in response to events at an automated banking machine.

It is a further object of the present invention to provide a system for obtaining image data and for taking actions in a sequence which can be programmed more readily.

It is a further object of the present invention to provide a system which achieves greater assurance of capturing useful image and transaction data related to transactions conducted at an automated banking machine.

It is a further object of the present invention to provide a system that provides selective remote notification of events and conditions occurring at an automated banking machine.

It is a further object of the present invention to provide a system that simplifies the recording, storage and analysis of transaction and image data generated at an automated banking machine.

It is a further object of the present invention to provide a system for imaging documents at an automated banking machine.

It is a further object of the present invention to provide a system that enables analysis of documents presented at an automated banking machine.

It is a further object of the present invention to provide a system for obtaining and storing image data related to servicing activities conducted at an automated banking machine.

It is a further object of the present invention to provide methods of recording, storing and analyzing image and transaction data produced in the operation of an automated banking machine.

It is a further object of the present invention to provide an image capture system that captures images in response to triggering events and which captures images in accordance with a programmed sequence of actions.

It is a further object of the present invention to provide an image capture system in which the triggering event is the occurrence of an image condition within a field of view of a camera.

It is a further object of the present invention to provide an image capture system in which images are captured in response to a triggering event which includes changes within a selected detection area within a field of view of a camera.

It is a further object of the present invention to provide an image capture system which captures images in response to a triggering event which includes the presence of a particular characteristic, object, facial feature or color within an image.

It is a further object of the present invention to provide an image capture system that can provide remote notification of a triggering event and to include with the notification an image associated with the event.

It is a further object of the present invention to provide an image capture system which provides for selective deletion of images by the type of event with which the image is associated.

It is a further object of the present invention to provide an image capture system in which images may be sorted and searched by parameters or combinations of parameters.

It is a further object of the present invention to provide an image capture system which provides for transferring images in a manner which provides enhanced assurance that the transferred images have not been altered.

Further objects of the present invention will be made apparent in the following Best Modes For Carrying Out Invention and the appended claims.

The foregoing objects are accomplished in one exemplary form of the present invention by a system which includes an automated banking machine. The automated banking machine carries out transactions by performing several transaction functions. At least one camera is positioned adjacent to the automated banking machine. The camera operates to produce camera signals which represent images within a field of view of the camera.

The system further preferably includes a computer in operative connection with a data store. The computer includes a server operating in connection with the computer. In some embodiments of the system the server may be resident and a part of the computer within the automated banking machine. In other embodiments the server may reside in a location adjacent to or disposed from the automated banking machine. The computer is in operative connection with the machine and the camera. The computer operates in accordance with programmed instructions to include image data corresponding to the camera signals in the data store. The image data is stored in response to the machine carrying out transaction functions.

The server is in connection with an electronic communications network. In some embodiments this may be a direct connection, local area network or an intranet. In other embodiments the network may be a telecommunications network, wide area network or the Internet. Alternatively the network could include a wireless network such as an RF network or satellite network. A user terminal disposed from the automated banking machine is connected to the network. The user terminal may be connected directly to the network or may be connected through one or more intervening networks and servers. The user terminal includes a computer with a browser operating therein as well as an output device such as a screen or printer. The user terminal through the browser accesses the image data through the server. The user terminal operates to output the image data through its output device. The user terminal also is used to access transaction data related to transactions corresponding to image data stored in the data store associated with the server. The user terminal may be operated to more rapidly analyze and sort image and transaction data, as well as to conduct a more detailed analysis of image or transaction data.

Embodiments of the system also operate in accordance with sequences of instructions. The sequence instructions provide for a sequence of actions to be taken in response to certain conditions. For example if in the course of capturing image data, a camera adjacent to the ATM is unable to produce usable video, such as because it is covered or due to glare, the instructions in the sequence may cause the system to begin capturing image data from another nearby camera. Other sequence instructions may avoid recording the image data for selected transactions. Other sequence instructions may cause the recording of images associated with service activities. This may be done with cameras located in service areas such as behind an automated teller machine or within the automated teller machine itself. Selective motion detection and other hard and soft triggers may be used to initiate recording of images and/or other actions which are part of a sequence.

Alternative embodiments of the invention also provide messages through the network indicative of conditions or events occurring at the automated banking machine. Further embodiments of the system operate to manage available memory. This may include projecting when available memory will likely be depleted and sending a message which indicates such condition. Other embodiments may reconfigure available memory or may automatically delete selectively certain image data or off-load data in memory through the network to a remote storage location. Further alternative embodiments of the invention provide for imaging of documents deposited in the machine. Image and transaction data associated with the deposit of documents may be recovered. Analysis of document image data such as signature analysis may be conducted through the network remotely from document verification terminals which include data usable to verify the genuineness of deposited documents.

Alternative exemplary embodiments of the invention are used independent of an automated transaction machine to capture image data selectively in response to triggering events. Such triggering events operate to cause the system to execute sequences which may include the capture of additional images or to take other actions including the remote notification of persons electronically of the occurrence of triggering events. Such notifications may include or have attached thereto at least one image file corresponding to an image associated with the event for which notification is being given.

In certain exemplary embodiments the triggering events include certain image conditions. Image conditions may correspond to the blocking of a camera in a way that prevents the delivery of usable video. Alternatively image conditions may correspond to the detection of motion, colors, objects, facial features, clothing, body positions, or other characteristics or items within a field of view of a camera. Exemplary embodiments of the invention enable a user to select one or more subsets of the field of view as a detection area and to sense for motion or other image conditions only within the detection area while ignoring image conditions outside the detection area. This facilitates the detection of desired events and avoids the use of available image storage in response to capturing images which are not of interest.

Exemplary embodiments of the invention also store image data and other data associated therewith so as to provide enhanced searchability of images. Embodiments of the invention enable searching through images selectively by one or more parameters. Such parameters may include the type of triggering event causing the image to be captured. Other exemplary parameters may include transaction types with which an image is associated, or time periods during which images are captured. Other parameters for the searching of images may include searching by color, object type, facial features or other characteristics. Such capabilities enable images to be identified, recalled and analyzed selectively, more quickly or in greater detail than is possible with existing systems.

Exemplary embodiments of the present invention also enable the transfer of images that bave been captured in a manner that provides greater assurance that the images have not been subject to alteration. Such capability assures that the image has greater evidentiary value in the event that it is used to establish liability related to the occurrence of transactions or events.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a schematic view of an exemplary embodiment of a transaction record system of the invention used in connection with an automated banking machine.

FIG. 2 is a schematic view of a control system for devices within an automated banking machine wbich incorporates a first embodiment of a transaction record system of the invention.

FIGS. 3 and 4 are schematic views of the relationship between the logical components which make up embodiments of the transaction record system of the invention.

FIG. 5 is a schematic view of the operation of the logical components of an embodiment of the invention operating to detect motion in the field of view of a camera used in connection with an embodiment of the invention.

FIG. 6 is a schematic view of the operation of logical components of an embodiment of the invention responding to a hard trigger type input.

FIG. 7 is a schematic view of the logical components of an embodiment of the invention responding to a soft trigger input.

FIG. 8 is a schematic view of the operation of the logical components of an embodiment of the invention responding to loss of usable video from a camera.

FIG. 9 is a schematic view of the logical components of an embodiment of the present invention operating in connection with a user identification system which identifies a user based on visible properties associated with the user.

FIG. **10** is a schematic view of an alternative embodiment of a transaction record system of the present invention in which an image server resides with other servers which operate the automated banking machine.

FIG. **11** is a schematic view of a further alternative embodiment of a transaction record system of the present invention in which the image acquisition devices are separate nodes on a network.

FIG. **12** is a schematic view of a further alternative embodiment of the transaction record system of the present invention in which the image acquisition devices reside in a second network.

FIG. **13** is a schematic view of a further alternative embodiment of the present invention which includes an automated banking machine with a document imaging device.

FIGS. **14** and **15** are a schematic view of logic flow associated with memory allocation and control used by embodiments of the present invention to provide greater reliability in storing image and transaction data.

FIG. **16** is a screen presented in an exemplary embodiment of the invention at a user terminal describing functions performed by an exemplary system of the invention and categories of persons generally authorized to perform such functions.

FIG. **17** is a exemplary embodiment of a screen presented at a user terminal for purposes of viewing and analyzing image data.

FIG. **18** is a screen presented at a user terminal in an exemplary embodiment of the invention for purposes of explaining the functions of icons shown in FIG. **17**.

FIG. **19** is a view of an exemplary screen similar to FIG. **17** but with a selected image enlarged for purposes of analysis.

FIG. **20** is a view of an exemplary programming screen used in an embodiment of the invention.

FIG. **21** is an exemplary embodiment of a daily program screen presented at a user terminal in an embodiment of the invention.

FIG. **22** is an exemplary embodiment of a setup screen displayed at a user terminal.

FIG. **23** is an exemplary embodiment of a setup screen presented at a user terminal for purposes of setting image compression types and for programming sequences.

FIG. **24** is an exemplary embodiment of a screen presented at a user terminal for purposes of establishing user access capabilities.

FIG. **25** is an exemplary screen presented at a user terminal for purposes of establishing image and data capture parameters during the carrying out of transaction functions at an automated banking machine.

FIG. **26** is an exemplary embodiment of a screen presented at a user terminal for purposes of input and editing e-mail addresses used for sending messages related to conditions and events occurring at an automated banking machine.

FIG. **27** is an exemplary embodiment of a screen presented at a user terminal for purposes of setting up an e-mail group including e-mail addresses of persons to be notified in response to the occurrence of conditions and events at an automated banking machine.

FIG. **28** is a schematic view of an alternative embodiment of an image capture system of the present invention.

FIG. **29** is an exemplary screen presented at a user terminal for purposes of operating and controlling the capture and presentation of captured images in the system of FIG. **28**.

FIG. **30** is a detailed view of the tool bar and icons presented in the screen shown in FIG. **29**.

FIGS. **31** and **32** are a chart showing the icons presented in the tool bar shown in FIG. **30** and the functions and operations in the programming of the exemplary system associated with each.

FIG. **33** is an exemplary screen presented to a user in operation of the exemplary system shown in FIG. **28** for purposes of configuring the selective deletion of image data.

FIG. **34** is an exemplary screen presented at a user terminal in the system of FIG. **28** for purposes of setting up an automatic delete function for selectively deleting types of captured images.

FIG. **35** is an exemplary screen presented at a user terminal for configuring and programming the exemplary system to apply enhanced security to captured images.

FIG. **36** is an exemplary screen presented at a user terminal for purposes of applying descriptive names to cameras, which descriptive names may be used in programming sequences.

FIG. **37** is an exemplary screen presented at a user terminal which enables a user to assign descriptive names to outputs which may be provided by the system as part of sequences.

FIG. **38** is an exemplary screen presented at a user terminal which enables a user to assign descriptive names to inputs which the image capture system may receive.

FIG. **39** is an exemplary embodiment of a screen presented at a user terminal for purposes of capturing images in response to triggering events which occur in the operation of an automated banking machine.

FIG. **40** is an exemplary screen presented at a user terminal for purposes of establishing e-mail addresses and groups of e-mail addresses which are to receive e-mail messages in response to the occurrence of certain triggering events in the system.

FIG. **41** is an exemplary embodiment of a screen presented at a user terminal for purposes of setting up a group of e-mail addresses for persons who are to be notified of certain events occurring at the system.

FIG. **42** is an exemplary embodiment of a screen presented at the user terminal for purposes of programming the system with sequences.

FIG. **43** is an exemplary screen presented at a user terminal which graphically displays sequences applicable to particular times and dates that have been programmed into the system.

FIG. **44** is an exemplary screen presented at a user terminal showing the times each day certain routine program sequences are carried out.

FIG. **45** is an exemplary embodiment of a screen presented at a user terminal representative of the steps taken by a user in programming a sequence.

FIG. **46** is an exemplary embodiment of a screen presented at the user terminal for purposes of establishing a programmed sequence in response to inputs received by the system.

FIG. **47** is an exemplary screen presented at a user terminal for purposes of displaying the times during which the sequence applicable to a particular input will cause a system to operate.

FIG. **48** is an exemplary screen presented at a user terminal associated with programming a sequence in response to receipt of a particular input by the system.

FIG. 49 is an exemplary screen presented at a user terminal for purposes of configuring a sequence for capturing images in response to detection of motion.

FIG. 50 is an exemplary screen presented at a user terminal for purposes of establishing a detection area as a subset of a field of view of a camera for purposes of selectively detecting motion within the detection area.

FIG. 51 is an exemplary screen presented at a user terminal for purposes of showing when a sequence applicable to detection of motion will be operative within the system.

FIG. 52 is an exemplary screen presented at a user terminal for purposes of programming a sequence to be carried out in response to detection of a motion event.

FIG. 53 is an exemplary screen presented at a user terminal associated with programming a sequence for detecting lack of usable video from a camera in which a camera is selected.

FIG. 54 is a screen similar to that in FIG. 53 showing how the screen after a camera is selected in response to presentation the screen shown in FIG. 53.

FIG. 55 is an exemplary screen presented at a user terminal for enabling a user to select a degree of change in an image for purposes of detecting motion in an image.

FIG. 56 is an exemplary screen presented at a user terminal indicative of when a particular motion detection sequence will be executed by the system.

FIG. 57 is an exemplary screen presented at a user terminal for purposes of programming a sequence to be executed in response to a lack of usable video condition.

FIG. 58 is an exemplary screen presented at a user terminal for purposes of establishing a sequence for capturing images at an automated banking machine.

FIG. 59 is an exemplary screen for establishing a sequence for capturing images in connection with a particular type of transaction and enabling a user to selectively input times at which images will be captured as well as the rate of image capture.

FIG. 60 is an exemplary embodiment of a screen presented at the user terminal for purposes of programming a sequence and demonstrating the capability of a user to establish the image capture rates as well as the image quality associated with storage of captured images.

FIG. 61 is an exemplary embodiment of a screen presented at a user terminal for purposes of a user selecting the recovery of images by various parameters.

FIG. 62 is an exemplary screen presented at a user terminal showing icons presented as a control panel and images recovered in response to a search.

FIG. 63 is a view of the screen similar to FIG. 62 but including representations of images captured as continuous video in AVI form.

FIG. 64 is an exemplary embodiment of a screen presented at a user terminal in response to a search in which the search results show that a plurality of images have been captured in response to a triggering event.

FIG. 65 is a view of a screen similar to FIG. 64 including representations that images have been captured as continuous video in response to certain triggering events.

FIG. 66 is an exemplary embodiment of a screen presented at the user terminal showing a plurality of images captured in response to a single triggering event.

FIG. 67 is an exemplary embodiment of a screen presented at a user terminal showing an image output in which images are not grouped by particular event type.

FIG. 68 is an exemplary screen similar to FIG. 67 in which the presented indicia indicates that the image has been grouped with a particular event.

FIG. 69 is an exemplary embodiment of a screen presented at a user terminal in response to search results obtained in response to a quick viewer routine in which a user is enabled to navigate through images by selecting buttons on the control panel.

FIG. 70 is an exemplary embodiment of a screen presented at the user terminal of a quick viewer page showing a single image with the selected image in enlarged format.

FIG. 71 is an exemplary embodiment of a screen presented on a user terminal in which a user is enabled to view images.

FIG. 72 is an exemplary embodiment of a screen presented at a user terminal which displays images selected for purposes of preview for printing or transfer in an "image cart" which enables such images to be downloaded.

FIGS. 73 and 74 are a chart indicating the features associated with the different search results shown in FIGS. 62 through 72 and the features and capabilities of the images associated therewith.

FIG. 75 includes a chart of indicia and information displayed with images which can be searched in the exemplary embodiment of the invention.

FIG. 76 is an exemplary embodiment of the control panel displayed on screens of a user terminal in connection with the presentation of search results.

FIG. 77 is an exemplary embodiment of an image counter presented in connection with the control panel shown in FIG. 76.

FIGS. 78 through 80 are charts showing the various functions performed by selection of icons in the exemplary control panel when particular image pages are being displayed.

FIGS. 81 through 83 are schematic views showing the operation of the icons included in the exemplary control panel screen in navigating through images which are presented to a user at a user terminal.

FIG. 84 is a chart explaining variations in an icon used in connection with designating images for deposit into an image cart for purposes of downloading images as a group, and the functions associated with the icon.

FIG. 85 is an exemplary embodiment of a screen presented at a user terminal for purposes of providing the user with greater image integrity assurance for downloaded images and a unique key or password for purposes of enabling the unlocking of such images.

BEST MODES FOR CARRYING OUT INVENTION

Referring now to the drawings and particularly to FIG. 1 there is shown therein an exemplary embodiment of the present invention which operates as a transaction record system for an automated banking machine generally indicated 10. The system of this embodiment includes an automated banking machine 12 which in this example is an ATM. It should be understood that in other embodiments of the invention other types of automated banking machines may be used. ATM 12 includes a number of transaction function devices. These transaction function devices are associated with components of the machine such as a card reader 14 and a keypad 16. The card reader and keypad serve as input devices through which users can input instructions and information. It should be understood that as referred to

herein the keypad includes function keys or touch screen inputs which may be used in other embodiments to input data into the machine.

ATM **12** further includes additional transaction function devices. Such transaction function devices may include a presenter schematically indicated **18** which operates to present cash or other documents of value to a customer. The presenter **18** in the embodiment shown is associated with a dispenser schematically indicated **20** (see FIG. **2**). The dispenser is operative to obtain sheets such as currency bills from within the machine and to deliver them to the presenter in the described embodiment. In alternative embodiments only a presenter or a dispenser may be used. The exemplary ATM **12** further includes a depository **22**. The depository **22** accepts deposits from customers. In the embodiment shown the depository is generally configured to accept cash and other instruments such as checks from a customer. It should be understood that in other embodiments other types of depositories which accept various types of items representative of value may be used.

The transaction record system of the described embodiment further includes a first camera **24**. Camera **24** is positioned within or behind the fascia of the ATM or otherwise adjacent the ATM so as to have a field of view which generally includes the face of the user operating the ATM. A further camera **26** is positioned adjacent to the ATM and includes a field of view which includes a profile or other view of the user operating the ATM.

A further camera **28** in this exemplary system is shown positioned adjacent to the ATM with a field of view to observe a service area of the ATM. Camera **28** in the exemplary embodiment shown is directed to observe the back of the ATM and is usable for observing or detecting service activities. Camera **28** may be for example positioned within a vestibule or room which is accessed by service personnel for purposes of servicing the ATM. A further camera **30** shown schematically, is positioned adjacent the ATM and within the interior of the cabinet of the ATM. Camera **30** is shown having a field of view which is directed generally opposite to that of camera **28** and enables it to view areas which would normally include the face and hands of servicing personnel. Camera **30** preferably operates when a service door **32** is open and a servicer is accessing the interior of the machine. This enables capturing image data related to persons servicing or accessing the interior of the machine.

In the embodiment shown each of the cameras **24, 26, 28, 30** provides camera signals which are analog signals representative of what is observed within the field of view of the respective camera. It should be understood that the camera configuration shown in FIG. 1 is exemplary and other configurations of cameras, or greater or lesser numbers of cameras, may be used in connection with embodiments of the invention. It should further be understood that embodiments of the invention may include digital cameras or other types of devices from which images may be reproduced.

FIG. **2** shows a schematic view of a first hardware configuration of a transaction record system of the invention. The automated banking machine **12** includes the transaction function devices **14, 16, 18, 20, 22** which communicate through and are operated responsive to signals passed through device interfaces **34**. The device interfaces communicate with the transaction function devices on an interface bus **36**. The messages which control operation of the various transaction function devices are communicated through the interface bus. A computer which is referred to as a terminal controller **38** operates the ATM by sending messages to the device interfaces to control the transaction function devices.

In the embodiment shown in FIG. **2** an image recorder device **40** is shown connected to the interface bus **36**. Image recorder device **40** in the embodiment shown is a separate hardware component from the automated banking machine. Image recorder device **40** includes a computer which includes a server operating therein, and further includes a data store schematically indicated **42**. The data store holds programmed instructions. The data store also holds data representative of image data, transaction data and other data as later described. It should be understood that although a data store within the image recorder device is described in the exemplary embodiment, reference to a data store herein encompasses either a single data store or a plurality of connected data stores from which data may be recovered.

Image recorder **40** receives the analog signals from the connected cameras **24, 26, 28** and **30** as shown. It should be understood that embodiments of the invention may include devices which in addition to image data, acquire sound data, infrared signal data and other types of data which can be sensed by sensing devices, stored, recovered and analyzed by the system. Image recorder device **40** further includes inputs which are schematically represented as hard and soft triggers. Hard triggers, examples of which are hereinafter described, are signals from "hard devices" such as sensors. Such devices can generally sense actions or conditions directly such as that a service door on the ATM or to a service area has been opened. The image recorder device also receives soft triggers which may include signals representative of conditions or instructions which are being sent as signals to other devices. Such soft triggers may further include the signals on the interface bus **36** in the embodiment shown or timing signals or other signals usable to operate the image recorder responsive to programmed instructions, time parameters or other conditions or signals.

Soft triggers may also include timing functions. In some embodiments the image recorder may monitor other types of transaction messages and may operate in response thereto. Such alternatives may include for example, systems where the image recorder device **40** is not connected to the bus with the transaction function devices, but instead monitors transaction messages being sent between an automated banking machine or other device and a remote computer, and extracts information concerning the operation of transaction function devices from such messages. Other configurations and operational capabilities of the image recorder device will be apparent to those skilled in the art from the description herein.

Image recorder **40** in the exemplary embodiment is in communication with an electronic communications network schematically indicated **44**. Network **44** in the described embodiment may be a local area network such as an intranet or may be a wide area network such as the Internet. In the embodiment shown network **44** is a network that communicates messages in protocols such as TCP/IP. The network is used,to further communicate HTTP messages including records such as HTML, XML and other markup language documents. Of course in other embodiments of the invention other communications methods may be used.

The image recorder device **40** includes a computer operating at least one server. The server is connected to the network and has at least one uniform resource locator (URL) or other system address. This enables the server to be accessed by other terminals connected to the network as well as to selectively deliver messages to connected terminals. It

should be understood that network **44** may be connected through intermediate servers to other networks. This enables the image recorder device **40** to communicate with other types of remote terminals including terminals connected to wireless interfaces such as pagers and cellular phones. If network **44** is an intranet, intermediate servers which operate as a firewall may be included in the system. Access to the Internet enables the communication of messages to terminals located anywhere in the world. Such communications capability may be valuable in embodiments of the invention for purposes of image and transaction data recovery and analysis, and for purposes of sending messages to individuals to be notified of conditions which exist at the automated banking machine.

A plurality of terminals **46** are shown connected to the network **44**. Terminals **46** may include a user terminal for purposes of programming parameters into the data store **42** of image recorder device **40**. Alternatively terminals **46** may include user terminals which may be used to analyze and recover image data and transaction data from the image recorder device. Alternative terminals **46** may include data stores for storing image and transaction data which is downloaded from the image recorder device for purposes of storage as later described herein. Alternative terminals **46** may include document verification terminals for verifying the authenticity of documents, identifying user data or for carrying out other functions described herein. Typically terminals **46** include computers including a browser component schematically indicated **48**. The browser communicates with the server in the image recorder device to access the image data. Such a browser component may be commercial browsers such as Netscape Navigator™, Microsoft Internet Explorer™ or other types of browsers. Terminals **46** also include other software and hardware components schematically indicated **50** suitable for processing image data, transaction data and other data that may be obtained by accessing the server in the image recorder device **40**.

An exemplary terminal indicated **52** is shown in greater detail in FIG. 2. Exemplary terminal **52** may be a user terminal, document verification terminal, data storage terminal, data analysis terminal or other type of terminal for inputting instructions or analyzing data available in the system. Terminal **52** in the exemplary embodiment includes a computer schematically indicated **54** which includes an associated data store schematically indicated **56**. As with other data stores described herein, data store **56** may be a single data store or a number of operatively connected data stores. Terminal **52** further includes in operative connection with the computer **54**, input devices **58** and **60** which include a keyboard and mouse respectively in the embodiment shown. Of course in other embodiments other types of input devices may be used. Terminal **52** further includes output devices. The output devices in the embodiment shown include a monitor with a display **62** and a printer device **64**. Of course in other types of terminals other types of output devices may be used. The terminal **52** includes a computer with a browser component as previously described. The browser in the terminal communicates with the server in the image recorder device **40** through the network **44** for purposes of carrying out the functions later described in detail herein. Terminal **52** may also have a server operating therein as well as other software components.

The operation of exemplary embodiments of the invention are further described with regard to the interaction of logical components of the system described in connection with FIGS. **3** through **9**. It should be understood that the logical components are generally combinations of software and hardware used in carrying out the described functions. As shown in FIG. **3** the input signals from the cameras, microphones or other input devices are input to the device switching controller component **66**. The device switching controller component in embodiments of the invention may include several components. The switching controller delivers signals, which in the described exemplary embodiment are analog signals, selectively in response to a record acquisition control component **68**. The record acquisition **68** component receives hard and soft trigger signals including signals which control or otherwise indicate the operation of the transaction function devices in the automated banking machine or other signals which are used as an indicator to initiate a sequence of actions. The record acquisition component executes the instructions which indicate which image signals are desirable to process and record in response to the trigger signals. The record acquisition component further includes or works in connection with stored instructions, which are operative to detect conditions such as loss of usable video from a camera or other input device, and to begin acquisition of data from other devices in response thereto.

The exemplary record acquisition component also operates in connection with stored programmed instructions to sense motion in the field of view of selected cameras or other input devices. As later described such instructions may include limiting the area of analysis to one or more selected detection areas within a field of view, and disregarding other areas. The record acquisition component may further process and pass off other data such as transaction data related to the operation of an automated banking machine for storage in correlated relation with image data. In some embodiments of the invention transaction and other numerical type data is selectively captured and stored in file records that are maintained separately from image data. Such transaction data may be correlated with image data at the time (which also indicates a date or other period of time) associated with the activity which is recorded for both image and transaction data. However in other embodiments of the invention other methods for such correlation may be used.

In this exemplary embodiment the record acquisition component in accordance with programmed instructions further controls encryption techniques used in connection with image data, as well as data compression techniques which are used for storing images. The record acquisition component may further operate to store data and control other activities such as the sending of e-mail or other messages in response to the occurrence of certain conditions.

The record acquisition component **68** in this embodiment operates to send one or more camera signals to a frame grabber component **70**. The frame grabber component is operative to generate digital image data corresponding to the analog camera signals which are passed to the frame grabber by the record acquisition component. Of course in embodiments where digital cameras are used the image data does not need to be digitized by a separate component. The image data from the frame grabber in this exemplary embodiment is passed to an encryption/authenticate component **72** which may be operated to include authenticating information within the image data. Such authentication data may include digital signatures, digital watermarks or other data which can be used to verify that an image has not been tampered with since it was acquired. In addition component **72** may operate to encrypt image data so as to minimize the risk of such data being accessed by unauthorized persons. In alternative forms of the invention such an encryption component may not be used.

A data compression component **74** may operate to compress the image data to minimize the amount of storage required for holding it. Such data compression may be performed through a number of different standard or non-standard schemes. The degree of data compression may be selectively controlled. In this exemplary emhodiment of the invention, the degree of data compression is programmable and may he changed through real time inputs or may he programmably controlled to change the degree of data compression. For example instructions stored in connection with the record acquisition component **68** may dictate that in response to certain events which are detected through hard or soft triggers, high quality image acquisition is required. In such cases data compression may not be used or a lesser degree of data compression may be used, to increase the quality of the images. Of course in such circumstances the record acquisition component may also increase the frequency at which images are captured from various input devices. In some instances, the image capture frequency may be increased to the extent that clips of generally visually continuous images are captured and stored.

After the image data is compressed it is transferred to a RAM cache store component **76**. The RAM cache store stores the image and transaction data (and other system data that the record acquisition component may dictate be stored for a period of time). It should he understood that emhodiments of the invention may operate to analyze cache store data for purposes of detecting and analyzing image and transaction data and for taking action in response thereto in accordance with programmed instructions. In some embodiments of the invention the record acquisition control component **68** operates to place images in storage from all cameras on a regular or nonregular periodic basis. These records initially do not correspond to any triggering event. However, embodiments of the invention may operate in response to programmed instructions when a triggering event occurs to associate one or more images immediately proceeding the triggering event to be associated with the images captured in response to the triggering event. This enables embodiments of the system to capture and retain those images of conditions which existed prior to an event. Such images may often provide valuable information concerning activities that preceded and/or caused the event.

In this exemplary embodiment, from the RAM cache store, image and transaction data is transferred in the system to a disk cache store **78**. From the disk cache store **78**, image and transaction data is suhsequently transferred to an archive store component **80**. The archive store component may in some emhodiments be a permanent or temporary storage media such as a removahle storage media as hereinafter descrihed. Alternatively the archive store disk may he a CD-R/W type device or similar storage media which may provide temporary or permanent non-modifiable storage of image and/or transaction data. Alternatively various types of storage devices that may he off loaded or overwritten may be used.

The archive store component operates in connection with a file management component **82**. The file management component **82** operates in accordance with programmed instructions to perform various operations. The file management component works in connection with other components to provide access to stored image and transaction data. The file management component also enables control of availahle memory to facilitate storage of data and minimize the risk that transaction and image data will be lost.

As represented in FIG. **4** the file management component **82** may work in connection with interface **84** to provide access through an intranet schematically indicated **86**. As previously mentioned, terminals connected to the intranet may he used to access the stored data. A server **88** which operates as a firewall may be used to provide selective access to the intranet and to provide access to other networks. Such other connected networks may include a wide area network such as the Internet.

Alternatively an interface **90** may be used to provide access directly to the Internet schematically indicated **92**. Appropriate controls may he used to minimize the risk of unauthorized access such as passwords and/or public key encryption. Digital signatures, session keys and the like may also be used to limit access to authorized persons.

An interface **94** may he provided to telephone communications networks. This may be accomplished through a dial up connection or a cellular connection. Such an interface may be provided for purposes of sending messages such as pager, fax or voice mail communications selectively to remote users or facilities.

An interface **96** to a lease line or other dedicated communications line may be provided for purposes of providing for both messaging and data communication. Of course in other emhodiments other types of communications interfaces for communicating messages and for providing access to image and transaction data may be used. The particular configuration used will depend on the needs of the system and the capabilities of the remote communications method.

As discussed previously, the file management component **82** may be in operative connection with a fixed local storage component such as a data store schematically indicated **98**. The local data store **98** may in the embodiments of the invention include datahase software operating in a data store in connection with a processor or computer in the automated hanking machine. Alternatively the datahase may operate on the computer within the image recorder device **40** or in other computers operatively connected with the image recorder device.

In embodiments of the invention, the image recorder device **40** or a connected device may include an image and transaction data recorder schematically indicated **100** in FIG. **4**. The transaction data recorder operates to record image and/or transaction, or other data on a removable storage medium **102**, such as a CD-R/W or other storage device. Such a removable storage device may include a permanent storage media which requires periodic replacement, but which is not subject to later possible modification as is the case with erasable storage. Such removahle storage media may work in conjunction with other local storage or remote storage. Operating under the control of the file management component **82**, this feature may in embodiments of the invention enable storage of data in other data stores which accepts overflow data on a temporary hasis when the removable storage medium has become filled. When the removable storage media is changed, the recorded data in temporary storage in the other data store is transferred thereto. Alternatively, the file management control component may operate to periodically erase images and data as storage space is needed. This may be done selectively hased on the age of the image, the nature of the event causing image capture or other parameters. Of course other approaches may be used.

As previously discussed, the file management component **82** may alternatively operate to cause the computer within the image recorder device to off-load image and transaction data. The off-loading of data may he made to remote storage devices schematically indicated **104** associated with con-

nected terminal devices to which data may be sent through the network **44**. Of course in alternative embodiments of the invention other approaches and techniques may be used.

FIGS. **5** through **9** are schematic views which represent the operation of components comprising executable instructions in exemplary embodiments of the system. These components are preferably software components which operate in connection with the record acquisition component **68** and the device switching control component **66**. In FIG. **5** a logic flow associated with motion detection is shown. The inputs from the cameras or the other input devices are processed by a detection area definition component **106**. The definition component contains data and instructions representative of one or more detection areas in the field of view of particular cameras that are to be analyzed and/or disregarded for purposes of detecting motion.

In some systems motion may be occurring fairly frequently within a field of view of the camera, but such motion is not of interest and it is desirable to not capture image data in response to such motion. For example when a camera is located in the security area from which the serviceable components of the banking machine are accessed, motion may normally occur within a portion of the field of view of the camera while in other portions of the field of view motion only occurs when the machine is being accessed. A camera located in an ATM vestibule may have a window within its field of view. Activity occurring outside the window may not be of interest and optimally should not result in image data being recorded. Motion detected through the window is disregarded responsive programmed instructions in the motion detection component which excludes from the analysis movement detected within the window portion of the field of view.

A camera positioned in the interior of an ATM housing may detect motion even when the service door of the machine is not open. This may occur due to flashing LEDs or other indicators within the interior of the machine. The detection area definition component **106** may define detection areas that exclude such sources of light or motion from the motion detection analysis. In certain systems vibration or other regular movement may cause certain fixed objects to appear to move relative to a camera's field of view. The detection area definition component may be used to exclude from the analysis images of known objects within an area of normal movement. The detection area definition component establishes those areas of the field of view of each camera in which changes in the image indicative of motion are to be analyzed and/or those areas in which changes indicative of motion are not to be analyzed. It should be understood that the definition component may in alternative embodiments apply to other sensing devices such as infrared sensors or other sensor types which have a field of view for sensing regions in which activities are to be disregarded. It should also be understood that the definition component **106** may also be set such that all regions in a field of view which make up an image are analyzed for purposes of motion detection.

The detection area definition component may preferably be configured remotely by authorized users at user terminals connected to the network. This is preferably accomplished by inputs which divide portions of the field of view of each camera into one or more areas where detected motion is of interest and not of interest. Such areas are preferably designated graphically on the output screen of a user terminal and are readily changed by inputs from authorized users.

The detection area definition component communicates with a motion detection component **108**. The motion detection component includes instructions which operate to compare sequential images obtained from the camera inputs. In one exemplary embodiment this is done by comparing intensities or color of corresponding pixels in sequential images. The sequential images are analyzed at periods fairly close in time. Changes in intensity or color of corresponding pixels of greater than a threshold amount are counted or otherwise mathematically analyzed. Changes above the selected threshold for at least a selected number of pixels in the entire image or selected detection area(s) of the image, indicate a substantial enough change such that motion is considered to have been detected. When motion is detected in an area of interest the motion detection component signals a device within control component **110** which operates the device switching controller **66** and the record acquisition component **68** to acquire image data from the camera at which motion has been detected. The system may also move into more permanent storage image data captured prior to the triggering event depending on its programming.

It should be understood that the motion detection feature is only used to capture images from those cameras for which the system has been programmed to acquire image data based on motion detection. In the exemplary system shown, this is generally in the secure areas within the machine or an exterior area adjacent the area where a servicer performs operations. If the system is not programmed to acquire image data based on motion detection from a particular camera, motion within the field of view of that camera will not result in the more permanent storage of image data.

As previously discussed alternative forms of the invention may operate to capture images on a generally continuous periodic basis. Such images may be temporarily stored in a queue or other memory and erased after a period of time. Systems of the invention may be programmed such that motion detection may be determined based on comparisons of pixels which make up these digitized images. The detection of motion may also cause the system to operate in accordance with programmed instructions to retain one or more images from the queue that preceded image in which motion was detected, and to store these prior images in correlated relation with the images captured in response to the triggering event. This feature enables an operator to review the conditions in the field of view of the camera prior to the triggering event. Such information will often prove useful in determining conditions or activities which led up to the triggering event.

The memory configuration of the described embodiment provides advantages in that the system is enabled to capture image and transaction data while delivering image and transaction data from storage. As a result unlike prior art systems, the capture of image data does not have to be suspended while images are recovered or downloaded from the system. Further, the configuration of the system enables capturing image data from a number of sources virtually simultaneously. This solves a problem associated with certain prior systems which when configured to detect motion, operate to record only from a particular camera where motion has been detected. Other image data cannot be captured while image data is being captured from the camera where motion was detected. This presents opportunities for compromise of such systems by creating a diversion at a first camera and then carrying out improper activities within the field of view of another camera. The preferred form of the invention does not suffer from this deficiency as image data may be captured in a plurality of cameras virtually simultaneously, and triggering the capture of images based on detection of motion at one camera does not suspend

image capture from other cameras. The system can also be delivering image and transaction data to a remote location while concurrently capturing such data from a plurality of sources.

The motion detection feature may operate in connection with an analysis component **112**. The analysis component **112** may be used in various embodiments of the invention to determine various information of interest. This may include for example to measure how long it takes a particular servicer to perform particular service functions within a machine or within a service access area. Alternatively, the analysis component may be used to determine how long customers remain watching an output device on the banking machine before, during or after a transaction is completed. This may be used to provide information concerning the degree of interest that a particular customer or customers in general may have in a particular type of promotional presentation that is made at the automated banking machine or other output device. Such information may be recorded in connection with the data store and later used for further analysis. Such analysis may include in the case of the servicer, comparing performance of service providers or determining the relative ease of servicing of various types of machines or components. It can also be used to determine if, or for how long, a servicer had activity related to a component in the machine. In the case of customers and users, the analysis data may be used for targeting promotional type information to users in the future as well as for evaluating the effectiveness of marketing type activities presented through the automated banking machine. The functions performed by the analysis component **112** on the captured data will depend on the particular nature of the data to be analyzed, but such analysis may be facilitated by the availability of image and transaction data which is stored in correlated relation in the data store with the movement analysis data so that the validity of any conclusions made can be verified.

FIG. **6** schematically represents a further aspect of the operation of embodiments of the present invention. FIG. **6** represents an example of how the system operates to capture image and transaction data in response to hard trigger inputs. Such hard trigger inputs generally correspond to sensors which sense conditions or other activities adjacent to the machine. As schematically represented in FIG. **6**, a sensor **114** provides in input signal which is received by a hard trigger logic component **116**. The hard trigger logic component is operative to determine the nature of the input and to communicate with a timing/sequence logic component **118** which controls what occurs in response to the particular input corresponding to a triggering event.

For example the sensor **114** may be representative of a sensor which senses when a service door on an automated banking machine is opened. The executable instructions programmed in connection with the system include instructions which comprise a sequence which controls what is to happen when this event is sensed. The timing/sequence logic component **118** will generally include information that may be time dependent, and/or a sequence of actions which are to occur. The sequence may include for example having image data captured generally continuously from particular designated cameras while the door is open. The sequence may further include sending one or more e-mail messages to particular e-mail addresses through the network so that individuals are notified that the machine has been accessed. As different entities may have responsibility for servicing machines depending on the date of the week or time of day, the routing of such messages may be time dependent and the programmed instructions may operate to send the messages to different addresses depending on the time that the event occurs. Such messages may include electronic mail messages which have one or more of the images captured included therewith.

The timing/sequence logic component **118** works in connection with a device switching control component **120**. The device switching component **120** is operative to work in conjunction with the device switching controller **66** and the record acquisition control **68** to acquire image data from the selected cameras through the frame grabber. The device switching control component **120** may also be programmed in other embodiments to take other actions such as to operate or interface with alarm systems, automatic locking systems or other types of devices. In addition as previously described the timing/sequence logic component may also operate to temporarily acquire images from various cameras or other image capture devices on a periodic basis. The programmed instructions associated with the particular triggering event may include storing on a more permanent basis one or more images captured prior to the triggering event. These images may then be stored in correlated relation in the data store with the images related to the event. Such information enables an analysis to be made as the causes or events preceding the triggering event.

FIG. **7** is a schematic view of the operation of the system to acquire image and transaction data in response to soft trigger inputs. Such soft trigger inputs may include for example messages to or from transaction function devices on the interface bus within an automated banking machine. Alternatively such soft trigger inputs may include transaction messages transmitted between an automated banking machine and a host. Other types of soft trigger inputs may include receipt of other electronic messages either alone or in relation to other messages, so as to indicate a condition which requires image or transaction data acquisition. Other types of soft trigger events may be initiated in response to timing functions which operate based on programmed instructions and the current time, or which are timed from other events.

The soft trigger logic component **122** is operative to receive the soft trigger inputs and to analyze the nature of the conditions represented by the inputs received. For example the soft trigger logic component may determine based on software instructions stored in memory that particular signals on a bus or line being monitored represent the input of a customer card to a card reader and the account number associated with that card. In certain embodiments of the invention such account data is captured as part of the transaction record data and the input of such a card to the card reader is used as a trigger to capture image data so that there is a record of the user that input the card. Likewise messages indicative of the presentation of cash to a customer by a presenter may be detected and used as a further triggering event to capture image data.

In certain exemplary forms of the invention a series or set of images is captured in connection with a transaction carried out by a user in an automated banking machine. Such images in the set are preferably captured in response to the operation transaction function devices on the machine. Such images are stored and may be recovered and displayed together for later analysis. The storage of multiple images in a set related to customer transactions increases the likelihood that suitable images of the user and/or background will be acquired which may prove useful later if such images require analysis. In addition, the fact that account data and/or other transaction data is captured in connection with

the image data and can be correlated therewith, enables searching the transaction data to recover the image data associated therewith. For example, because the transaction data commonly captured may include the account number as well as the user name encoded on the card, the transaction data may be searched using these parameters. This enables readily identifying transactions corresponding to these parameters and retrieval of the image data associated therewith. This greatly reduces the time to locate pertinent images compared to other systems. In addition, other types of sorting parameters may be used to recover images. These include for example, time periods during which transactions were conducted, amounts of deposits, amounts of withdrawals or other transaction parameters. Any of these transaction parameters that are stored in connection with or which may be correlated to image data may be used to selectively identify and recover images. Of course in other embodiments other approaches to the capture of image data, transaction data and other types of soft trigger logic may be used.

Soft trigger logic component **122** operates in connection with a timing/sequence logic component **124**. The timing/sequence logic component is operative responsive to programmed instructions input by a user during setup of the system. The timing/sequence logic component operates to capture image and transaction data selectively from various cameras and/or transaction function devices depending on events that are occurring and/or the date and time of such events. For example if particular transactions are occurring the timing/sequence logic component may take special actions different or in addition to those taken with regard to other actions. An example may be when a customer seeks to deposit more than a certain amount of funds in the machine or seeks to cash or obtain value for an instrument. The timing/sequence logic component may capture more frequent images or images from additional cameras during the transaction. Another example may be in the case of a reportedly stolen card. If the soft trigger logic identifies the input card as stolen, the logic component may operate to not only acquire additional image data, but also to send messages through the system or through other communications channels to police or other authorities.

A further example may be used in connection with a banking machine which includes check accepting or other document accepting devices where the authenticity of the inserted document may require verification. The timing/sequence component may work in connection with an imaging device within the automated banking machine to capture an image of indicia on the inserted document, and to transmit an image of the document while the transaction is ongoing to a verification terminal in the network. Such a document may be viewed at such a terminal and/or electronically analyzed to compare the image of the document to verification information such as a handwriting or signature database for purposes of determining authenticity. The destination where such messages are sent may be varied depending on the nature and/or amount of the document, the time of day and other parameters depending on the instructions associated with the timing/sequence logic component **124**.

Other exemplary applications of timing/logic sequence include minimizing the use of available image data storage by reducing or eliminating the amount of image data acquired related to certain transactions. For example the timing/logic sequence may include instructions to capture fewer or no image data related to transactions conducted that are of certain types. This may be appropriate for example in the case of an account balance inquiry. Likewise the instructions may provide that a dispense of cash below a particular amount, such as for example $100, may not result in the acquisition of image data. Likewise, certain deposit transactions for certain customers within certain limits may not require the capture of image data, or may have the system capture a lesser number of images than is captured in connection with other transactions.

The timing/sequence logic component **124** may operate in connection with instructions that capture additional image data in connection with certain transactions by certain individuals. Additional image or transaction data may be captured based on selected time of day, or a combination of time and day, amount or the nature of the individual customer. Various schemes for using customer profile data, time of day data and other information accessible through the network may be used in combination with the soft trigger inputs to selectively control the image and transaction data capture capabilities, and the message sending and device control capabilities of the system in response to selected circumstances that may arise in the operation of the automated banking machine.

A device switching control component **126** operates responsive to the timing/sequence logic component to capture image data during the transaction. The device switching control component further operates to capture transaction data in connection with the transaction. This may include for example time and date data, account number data, amount data, transaction number data, user name data, machine location data and other data which can be derived from the soft trigger inputs or other information available to the machine. Such data may also include multiple items of similar data such as time data. This may be desirable for example when the ATM has an internal clock and the image storing device has its own associated system clock which may not be perfectly synchronized with the ATM clock. Capturing time data corresponding to both clocks may avoid confusion. Alternatively, programming may be provided for automatic clock synchronization and/or for obtaining time data or setting signals from another source.

In exemplary embodiments of the invention, the nature of the related data analysis can be set by the user during setup of the system. This is done through a user terminal and is preferably accomplished by selecting options in a setup window such as shown in FIG. **25**. The related data analysis and storage component **128** operates to capture and store the selected data. The data analysis and storage component is further operative to store the related transaction and other data in correlated relation with the image data. In certain embodiments of the invention such correlation is provided by storing data representative of the time and date associated with the image data and transaction data. In other embodiments other approaches to correlate the image and transaction data may be used.

In alternative forms of the invention the data storage and analysis component **128** may also include instructions for analysis of received data such as to provide statistical analysis related to use of the machine. Such data may be used in connection with developing a historical use pattern for the machine which may be used in connection with the memory allocation activities performed by embodiments of the system as later discussed herein.

FIG. **8** is a schematic view of the logic flow associated with operation of embodiments of the invention where a lack of usable video information is detected with a camera that is to be operated in the course of a transaction. It should be understood that the lack of a usable video logic may operate

in connection with the motion detection logic, hard trigger logic or soft trigger logic previously described.

A lack of usable video detection component **130** operates in response to executable instructions to determine if a camera that is or may need to be operated is not providing suitable image data. This is done in preferred embodiments by comparing pixel data from the areas of the image that are indicated to be of interest by the detection area definition component **106** or from the entire field of view. The lack of usable video component **130** determines if pixels which comprise an image are generally all above or all below certain intensity or color levels and/or are lacking in contrast across the image so as to not provide a suitable image. The logic may check for example if generally all pixels are indicated as dark, which may suggest that a camera is being blocked or a lens has been spray painted so as to obscure the camera. Likewise the logic may check to determine if the pixels are generally all above a certain intensity value which may indicate that a glare condition created by reflected sunlight or a light operated by a person is obscuring a camera. The lack of usable video components may also operate based on detecting a rapid, large change in the field of view, or such a large change followed by an extended period without any change. A lack of usable video may also be based on detection of certain relatively unchanging high contrast images or sensing an unchanging image in a selected portion of a field of view. The lack of usable video component **130** may also be operative to detect that the camera signals have been interrupted. Various approaches may be taken to making a determination that there is a lack of usable video.

A timing sequence logic component **132** operates responsive to component **130** to take action in response to the condition. The action is taken in accordance with a programmed sequence which is set up by a user and stored in a data store. The sequence may include for example responding to a lack of usable video by capturing image data from additional cameras. For example if in FIG. **1** camera **24** is unable to provide usable video, image data may be captured from camera **26**. The programming of the system may also operate in response to detecting a lack of usable video event to store in connection with the event one or more prior images that had been obtained and stored temporarily from the camera which is considered to be no longer providing usable video. Such images may be useful in determining the cause of the loss of usable video and/or the identities of persons which may have caused the loss of video.

In some exemplary embodiments the timing sequence logic component in response to the lack of usable video may cause the server component to generate a message to selected addresses in the network to indicate the nature of the condition. Such messages may include therewith one or more images. Likewise the timing sequence component may formulate messages to service entities responsible for repairing the system to indicate that there is a problem. In alternative forms of the invention the timing sequence component **132** may operate to perform activities through additional interfaces or computers such as turning on alarms, actuating additional lighting, contacting police authorities and/or disabling the automated banking machine. Such activities may be performed depending on the setup of the system as programmed by user.

The timing sequence logic component **132** operates in connection with a device switching control component **134**. The device switching control component operates to capture image data responsive to programmed instructions and may also interface with other devices and systems to carry out functions determined by the timing sequence logic.

FIG. **9** shows an alternative logic flow used in connection with embodiments of the invention in which features of a user are used to identify and/or authenticate the user or actions carried out thereby. The logic flow represented in FIG. **9** includes an identification data acquisition component schematically represented **136**. The identification data acquisition component in an exemplary embodiment operates to acquire data with a camera concerning a physical feature of the user. For example camera **24** may be used to acquire camera signals corresponding to a face of the user. An identification processing component **138** is used to compare the image data acquired to image data corresponding to a set of authorized users. Such authorized user data may be stored in a data store. As schematically indicated this data store may be within the automated banking machine or may be accessible through a network. Such identification processing may process not only user image data but also other data such as data from an object provided by a user, voice data, iris scan data, retina scan data or other data that can be used to indicate that a transaction is authorized.

If the identification processing component **138** is unable to identify the user then such information is provided to a machine control interface component **140**. The interface component prevents operation of the machine but operates the system to capture image data related to the person who was unable to operate the machine. Alternatively if the user is identified as an authorized user by component **138**, the machine control interface may authorize further operation of the machine, or may authorize such further operation if other indicia such as voice, numeric or other inputs correspond to the authorized user. Again the machine control interface component will operate to acquire image data concerning the authorized user. A data analysis storage component **142** operates to store data related to the transactions conducted by the authorized user and is operative to store transaction data in the data store. This may include the various types of transactions conducted by the user and may further include storing in correlated relation with the user data, data representative of instruments deposited by such a user, instruments produced for such an authorized user or other information related to the user's transaction which is stored for later recovery. The nature of the transaction information captured will depend on the nature of the automated banking machine and the image and transaction data captured in connection therewith.

The capture of images from the various cameras on a continuing basis in embodiments of the system may also be used for other purposes. For example, the facial features of criminals, missing persons or other individuals of interest may be stored in connection with the data store. The system may operate so that content of images captured on a continuing basis from cameras, or alternatively images captured in response to triggering events, are analyzed so that the facial features of persons in images are compared to images stored in the data store. Responsive to finding a match the system may operate in response to programmed instructions to trigger a sequence which may include capturing additional images, sounding alarms or sending messages electronically to selected individuals. Such messages may include therewith the captured images as well as information concerning the person who was indicated to be recognized. Such facial recognition may be carried out for example in embodiments of the invention using software such as Face-It™ software which is commercially available from Lernout & Hauspie. Of course in other embodiments, other components and approaches to recognizing persons and images may be used.

In addition, because embodiments of the invention include image data stored in response to transactions and other triggering events, the stored data may be retrieved using the parameter of facial features or a particular individual's appearance. This may be done for example to identify instances where a particular service person has worked on a particular machine. Alternatively transaction data may be reviewed to determine instances where a particular individual may have used the debit or credit cards of another person in conducting transactions. Numerous uses of searching through the image data using such parameters may be used.

Alternatively or in addition, the image data received by the system may be analyzed on a real time or periodic basis for the presence of other features in images. For example, images captured from a camera adjacent to an automated banking machine may be analyzed for the presence of certain objects which appear in the field of view of the camera. Such objects may include for example certain types of criminal tools used to attack the automated banking machine. Alternatively, objects which may be recognized may include certain types of weapons or other objects. Various body positions such as a person raising their arms or lying down might also be recognized. In response to a captured image having the image condition of including an object or characteristic which corresponds to one which is recognized by the system responsive to stored logic, appropriate responsive actions may be taken. Again, such actions may include sounding alarms, shutting down the automated banking machine and/or sending messages including messages which include images to programmed addresses or devices. Embodiments of the invention may operate in conjunction with or as part of a system as described in allowed U.S. patent application Ser. No. 08/813,511 which is owned by the assignee of the present invention and the disclosure of which is incorporated herein by reference as if fully rewritten herein. The identification of particular objects or features in the field of view of a camera may be operative to cause the dispatch of messages through one or more types of message media to predetermined recipients of such information. The dispatch of messages may include synthetic voice messages dispatched by phone or similar media, paging, radio messages or other types of messages. In addition, the responses to such messages may be monitored and tracked in accordance with programmed parameters to assure an appropriate response occurs.

A further advantage of embodiments of the present invention is that the stored image data is capable of being searched for other visual conditions or appearance features. For example, stored image data may be searched to uncover images which were stored of users with certain facial characteristics. Such characteristics may include features that may be recalled by another person of a potential witness to an activity which occurred in the area where the image capture system is operating. Such image capture capability enables images to be sorted to look for persons with features such as certain hair color, facial hair, skin color, tattoos, earrings, jewelry, or glasses as well as for certain types or colors of apparel. This may include for example hats, ski masks, bandanas, ties and jackets. The ability of the present invention to sort through image data and to recover images based on one parameter or a combination of parameters enables the recovery of images that using prior systems would require considerably greater time and effort. As can be appreciated from the foregoing description, embodiments of the invention provide many uses and advantages compared to prior art systems.

FIG. **10** is a schematic view of an alternative form of the transaction record system of the present invention generally indicated **144**. System **144** includes an automated banking machine which in the exemplary system is an automated teller machine schematically designated **146**. Automated teller machine **146** is similar to the ATM described in the previous embodiments in terms of its outward appearance and configuration. However the computer and software architecture of ATM **146** differs.

ATM **146** includes a plurality of transaction function devices **148**. The transaction function devices include devices which can be used to carry out transaction functions with the machine. These are similar to the transaction function devices of the previous embodiment. The transaction function devices generally include input devices such as a card reader, keypad, touch screen and/or function keys. The transaction function devices may also include devices for dispensing sheets and currency such as a bill dispenser and bill presenter. The transaction function devices may also include a depository, printing devices for printing transaction receipts, printing transaction records and other documents. The transaction function devices may also include a number of other devices.

The transaction function devices are operative in response to a device manager/interface component **150**. The device manager interface component may be comprised of applets, programs or other applications written in a language such as JAVA by Sun Microsystems or Active X by Microsoft. Component **150** preferably includes data and instructions which represent operational relationships among the devices, and such data and instructions are schematically represented by a data store in connection with component **150**.

The device manager/interface component **150** preferably operates the devices in response to HTTP format messages which are delivered by a device server **152**. The device server **152** similarly includes a plurality of applets or other programs which operate responsive to messages received by the device server. The device server contains the instructions which generally operate to control, coordinate and limit the operation of the transaction function devices within the ATM.

ATM **146** further includes a document handling portion **154**. Document handling portion **154** is operative to process HTML documents and HTTP messages which the document handling portion selectively accesses. The document handling portion **154** includes a browser for selectively processing HTML documents or other documents. The documents accessed by the browser may include therein instructions such as JAVA script which are processed by the browser and which are operative to cause a computer to output messages through an output device such as a screen display of the ATM. The document handling portion **154** of this example further includes a server device that is operative to output messages to the other components of the machine as well as to a network **156** to which the machine is connected. The document handling portion **154** may access HTML or other documents through a bank server **158** or other servers which are connected to the network **156**. The bank server **158** may also send and receive messages from the device server **152** and other components of the machine. As shown schematically, the bank server **158** is in operative connection with a back office processing system **160**. The back office processing system is operative to maintain data records and account information, as well as to provide information for generating documents and messages which are delivered by the bank server **158**.

It should be understood that ATM 146 may be operated through messages exchanged with plurality of servers which are connected to the network 156. This may include other bank servers directly connected to the network 156 as well as bank servers which are connected to a further network 162 which can be transmitted through a control server 164. An example of such a system would be a system in which network 162 is a wide area network such as the Internet and control server 164 serves as a firewall limiting the servers from which the automated teller machine 146 may receive instructions.

It should further be understood that the document handling portion 154, device server 152 and device manager/interface component 150 may in embodiments of the invention comprise components which communicate through the operating system of the computer on which the components reside, or may communicate on a local area network which operatively connects the components of the machine. It should further be understood that in other forms of the invention the machine may be connected directly to the wide area network.

In the exemplary embodiment of the invention shown in FIG. 10, the server component associated with an image recorder device resides on the computer which operates at least some of the transaction function devices of automated teller machine 146. An image server component 166 is resident on the computer within the automated teller machine and is accessible through the network 156 at an address on the machine. As in the prior embodiment, the image server is in operative connection with at least one data store 168. The data store 168 includes executable instructions carried out by the image server as well as image and transaction data. It should be understood that the data store 168 may represent a portion of overall memory available in connection with the computer operating the automated teller machine 146. Alternatively data store 168 may include a separate data store such as a recorder with a removable storage media or a combination of allocated storage available on the computer in the machine and a separate data storage device.

It should be understood that in certain embodiments of the invention the computer in the automated teller machine 146 operates in a Microsoft Windows NT® software environment and data storage is allocated between the components operating in the machine. Further the transaction data storage associated with the captured images accessible through the image server is shared with other transaction data storage maintained for transactions carried out by the machine, to reduce duplicate storage of data. Such transaction data storage information may be stored in the machine for purposes of archiving or accumulating batch data which may be later transferred to the back office 160 through the bank server 158 or to other locations. It should further be understood that in embodiments of the invention, image data may be downloaded to other devices connected to the network 156 and accessed therefrom while transaction data may be maintained in storage at the ATM or in a different data store within the network. The downloaded data may be erased or overwritten after downloading to provide added storage space at the machine. Alternatively image data may.be downloaded with or at generally the time of each transaction at the machine.

The exemplary form of the invention enables accessing image and transaction information from different locations. This is accomplished by coordinating image data and transaction data which may be accomplished in embodiments of the invention by including with the image data, data representative of source as well as information corresponding to a time associated with the transaction as previously described. This enables correlating the image data with the source transaction data corresponding thereto based on time and date. Of course other alternative approaches to recovering and correlating transaction and image data may be used.

As shown in FIG. 10 image server 166 is connected to a hardware interface schematically represented 170. Hardware interface 170 is shown connected to cameras 172 as in the previous embodiment. Hardware interface 170 of the exemplary embodiment performs the switching, acquisition control, digitizing and hard trigger receiving functions described in connection with the previous embodiment. Interface 170 may also be used to provide outputs for controlling camera aiming devices (such as pan/tilt/zoom), focus devices, lighting and other devices. It should be understood however that the allocation of such functions between a plurality of hardware and software components may be achieved in various ways within embodiments of the invention.

In the embodiment shown in FIG. 10 the image server 166 is in operative connection with components 150, 152 and 154 which are primary operational components of the ATM. Such configuration readily enables configuring the image server to cause the capture of image and/or transaction data in response to soft triggers which are in the form of events which are fired to components in connection with the server. Such programming may be readily accomplished through visual programming tools used in connection with programming in JAVA and other languages. Such programming tools may include Visual Age® by IBM and Visual Studio™ by Microsoft. Use of such programming enables readily establishing and changing the soft triggers for image and other data acquisition as well as readily changing actions which may be taken in response thereto.

As shown in FIG. 10 other terminal devices may be connected to the network 156. This may include user terminals 174 of the type previously described as well as verification terminals, data storage terminals and other types of terminals that work in connection with the system. Network 156 may be connected to interface devices schematically represented 176, which provide gateways to other communications mediums of the type previously described. Such gateways may be used for sending messages to servicers, police authorities or other persons who are to receive messages in response to events which occur at the ATM based on the sequence of configuration data for the capture of image data stored in connection with the image server or other computer.

As can be appreciated from the configuration in FIG. 10 an authorized user operating a user terminal can access image data by accessing the image server with a browser and recovering image data from memory. This configuration further facilitates analysis of image data by being able to correlate transaction activity and the operation of transaction function devices with image data. Further the capability of the exemplary embodiment of the invention to capture image and transaction data while virtually simultaneously delivering image and transaction data to a remote user, facilitates maintaining ATM 146 in operation. Actions in response to triggering events may include panning, tilting or zooming cameras which may be used to verify suspect lack of usable video events or as actions in a sequence. Other advantages of this embodiment due to the flexibility and the ability to readily make changes in configuration will be appreciated by those skilled in the art.

An alternative form of the system of the invention generally indicated **178** is shown in FIG. **11**. The system **178** includes an automated banking machine which is an automated teller machine generally indicated **180**. ATM **180** is similar to ATM **146** previously described except as discussed herein.

ATM **180** includes a computer which includes an image server **182**. Image server **182** operates in a manner similar to image server **166**. However image server **182** instead of acquiring image signals through a hardware device obtains image signals from a connected network **184**. In the system shown in FIG. **11** cameras **186**, **188** and **190** are each connected to a mini server **192**, **194** and **196** respectively. The cameras and mini servers are each operative to function as a network node in connection with network **184**. Each network node includes hardware and software which converts the camera signals to image pages or similar image files that can be transmitted through the network **184**. These images can be relatively spaced in time or close enough together to be considered as full motion. The programmable instructions executed in connection with image server **182** are operative to selectively access the cameras through the associated mini server and to download images therefrom. Such images may be stored as image data in correlated relation with transaction data in the data store within the automated teller machine. Alternatively image data may be stored in data stores associated with each of the mini servers so that it may be selectively accessed therefrom by image server **182** as well as from other authorized terminals within the network.

As can be appreciated, this alternative configuration further distributes the acquisition of image data and transaction data. However as the transaction data is accessible through the image server **182**, and the system location of the mini servers **192**, **194** and **196** are each known from their associated URL or similar system address, correlation and recovery of image and transaction data may be readily accomplished. It should further be understood that while in the configuration of the system shown in FIG. **11** each camera is shown with an associated mini server, a group of several cameras may be interconnected and may selectively deliver image data through a single mini server to the network. Alternative configurations may be used to suit the particular nature of the system being operated.

FIG. **12** shows yet another alternative system of the present invention generally indicated **198**. System **198** includes an automated banking machine which is indicated as ATM **200** which may be generally similar to ATM **146**. ATM **200** is connected to a network **202**. A computer including an image server **204** generally similar to image server, **166**, operates on ATM **200**. Cameras **206**, **208**, **210** and **212** operate to supply camera signals which are received by image server **204** through an interface **214**. In this embodiment the interface **214** is an interface to a second network schematically indicated **216** in which the cameras are connected. The interface **214** in one form of the invention is an interface to a power supply network to which cameras are connected. Interface **214** may be for example an interface to a power distribution system within a facility in which the ATM is operated. An X-10 technology type of communication may be used for example. Signals from the cameras **206**, **208**, **210** and **212** are superimposed on the power distribution line through a plurality of impedance matching interfaces **220**, **222** and **224** respectively. Signals sent by interface **214** are operative to cause selected ones of the cameras to output camera signals superimposed on the power distribution lines. Such image signals may be received at interface **214** and processed in the manner similar to other camera signals as previously described. Camera signals sent in the second network may take various forms of analog and digital signals and may be multiplexed or otherwise sent simultaneously so that image data may be acquired and captured selectively by each of the cameras as described in connection with the previous embodiments. Signals for controlling or positioning cameras may also be transmitted through the network as well as image data.

FIG. **13** shows yet another form of the invention referred to as system **226**. System **226** includes an automated banking machine **228**. Machine **228** is an ATM similar to ATM **146** except that it includes among its transaction function devices a check or other document imager schematically indicated **230**. ATM **228** operates to accept checks or other instruments from users of the machine in response to control by the other components. The imaging device **230** operates to produce document image signals representative of documents that may be deposited or received by a user in the machine. An image server **232** or a computer in which it operates is operative to cause the capture of images produced by the imaging device and store image data responsive thereto in the associated data store. In addition, the computer is operative to cause the machine to capture transaction data and/or to correlate transaction data captured by other components of the machine, with image data. Image server **232** and the associated computer may also operate in connection with cameras and other input devices similar to those discussed in connection with the previously described embodiments. The computer may further store camera image data in memory in correlated relation with document image data generated from the imaging device.

Image server **232** is in operative connection with a network **234**. Network **234** is in operative connection with a terminal **236**. Terminal **236** may serve as a document verification terminal. Terminal **236** has in connection therewith a verification data store schematically indicated **238**. Verification store **238** includes therein data representative of indicia which can be used to verify genuineness of documents input to the machine through the imaging device. For example verification data store **238** may include data representative of customer signatures and/or other identifying data for customers authorized to provide checks into the machine.

Document verification terminal **236** includes a computer including a browser therein. The terminal **236** is controlled responsive to input devices that access document image data through the image server **232**. The document verification terminal **236** operates responsive to the document image data to compare indicia in or associated with the document image data, to indicia stored in the verification data store. This may be done for example by comparing image data related to checks or similar documents input to the check imager **230** to images of known genuine signatures stored in data store **238**. Such indicia may be compared for genuineness by human comparison on a side-by-side basis by outputting such information to an output device such as a screen. Alternatively the data may be manipulated to place such signature data in overlapping relationship or in other relative positions so as to facilitate analysis thereof. Alternatively, verification terminal **236** may include instructions such as software programs which are operative to compare indicia in document image data to indicia stored in data store **238**. Such verification software may compare the signature data from the input document and the known genuine signature and provide an indication of suspect signatures or possible forgeries. This may be accomplished

by comparing the image data corresponding to contours of letters, portions of letters or combinations of letters within a signature, and indicating when a level of correspondence does not exceed a particular threshold.

Image server **232** may have associated instructions which causes document image data to be provided automatically periodically to verification terminals **236**. Alternatively image server **232** may be configured to operate in connection with other components of the machine to provide an indication during a transaction involving an instrument, and to forward such document image information through the network **234** so that the character or genuineness of the deposited document may be verified before the transaction is completed. This has the advantage in that when cameras are used in connection with the machine, an image of the individual operating the machine as well as the document image data may be viewed or processed before crediting or charging the customer's account for the value of the deposited or dispensed document respectively. The ability to capture the image of the customer along with the document image and to store the two in correlated relation further facilitates tracking and minimizes fraud. In addition, the verification terminal **236** may operate in the manner previously described in connection with user identification software which enables identifying a user by physical characteristics. This further minimizes the risk of fraud.

It should be further understood that although the exemplary embodiment has been described in connection with a document imager and an attended verification terminal **236**, embodiments of the invention may operate using unattended verification terminals such as terminal **240** which operates to carry out verification activities according to stored instructions without human interactions. Alternatively other forms of the invention may verify the authenticity of deposited documents through watermarks, holograms, inks having magnetic, fluorescent or other characteristics or other indicia which is indicative of genuineness of deposited documents. Other approaches and configurations may be used depending on the nature of the documents being accepted or dispensed and the indicia which must be compared or processed in order to determine the genuineness of the accepted document.

It should further be understood that features of the system shown in FIG. **13** may be applied to systems in which documents are printed with identifying indicia so as to enable more ready verification of their genuineness. This may include for example printing an image of a user on a check or other document dispensed by the machine. This may be done by the image server in response to image data from a camera which has the user in its field of view during the transaction. Such image data may be delivered by the image server to the printer which is one of the transaction function devices in the machine. The image data may be used by the printer to produce a document which includes the image of the authorized user. This reduces the risk of the document being presented by unauthorized persons. In addition or in the alternative a computer in connection with the image server may obtain image data concerning an authorized user, watermarks or other information from memory or from terminals connected to the network **234** or may generate one or more identifying numbers or other indicia, and include such information or indicia in printed documents it produces.

Further alternative forms of the invention enable correlating image and transaction data for documents received or produced by the machine. This enables users at other terminals which have access to the network **234** to verify the appearance features, such as the appearance of a person to whom a document was issued. This enables persons accepting such documents to verify the authority of the person presenting the document to possess it. In addition if the document is redeemed at another terminal, the image of the person redeeming the document may be compared to the image of the person who received the document to verify that the document is being redeemed appropriately. This may be done visually using an output device at the terminal where the document is redeemed or may be done at a remote verification terminal in the network by an operator or by image comparison software. Alternatively identifying indicia in a presented document may be checked for genuineness and/or validity. For example, the redemption of documents may be recorded and tracked, so that upon presentment a check is made as to whether the presented document has already been redeemed.

Similar principles may be applied with regard to data representative of value which is loaded onto smart cards or similar instruments. Data representative of the image of the person who has received the value may be stored in correlated relation with indicia corresponding to the transaction in which value is loaded and/or with identifying indicia associated with the card. Later when an individual presents that same card at the same or a different terminal, an image of the person presenting the card may be captured and/or the appearance of the person may be compared to the image data stored in memory. Image data of the authorized user may also be stored in memory on the smart card. Such image data may correspond to facial features. Alternatively image data may correspond to other features that are capable of being viewed by eye or read with the aid of a machine such as fingerprints and iris scans. Similar principles may be applied to other types of transaction systems and devices to minimize the risk for fraud and abuse.

Forms of the present invention may enable the management of available memory to minimize the risk that image data and/or transaction data related to transactions conducted at the machine will not be captured and stored in memory. FIGS. **14** and **15** schematically represent steps performed by certain forms of the invention to manage the amount of memory resources and to selectively off-load image data when necessary. In addition the exemplary form of the logic described in connection with FIGS. **14** and **15** is operative to estimate when memory resources such as a permanent image storage medium will become full based on transaction rates, and to forward a message to appropriate personnel of such impending loss of memory capability.

Referring to FIG. **14**, the logic flow commences with a step **242** in which a decision is made as to whether image data has been stored. If so, a determination of available memory is made in a step **244**. In addition a record is made as of the available memory as of the time and date of the transaction. This is done at a step **246**. The decision is then made at a step **248** as to whether the available memory is below a particular threshold. If so, certain actions are taken as described in connection with FIG. **15**.

If the available memory is not below the threshold as determined in step **248** a determination is made at a step **250** to calculate memory use over the preceding set number of days, hours or other time period. At a step **252** the calculation is then made as to a time to depletion (TTD) based on the current rate of memory use. The determination is then made at a step **254** as to whether the time to depletion (TTD) is less than a set number of days. If so, actions are taken similar to those taken when the available memory is below a threshold as described in connection with FIG. **15**.

If the time to depletion is less than the set threshold, the logic flow then operates to recall from memory historical use pattern data. This is done at a step **256**. This historical use pattern data may be information regarding the level of use of the memory based on the day of the week or other correlatable data for the machine over a period of time. Such pattern data may involve fuzzy logic or other programming which may make allowances for pay periods, holidays, vacation periods and other activities which are used to establish the historical model on which the pattern is based. Using the historical pattern data the logic flow calculates an estimated time to depletion based on the pattern data in a step **258**. The time to depletion based on the pattern data is then compared to the threshold in a step **260**. If depletion is expected to occur based on the pattern data in less time than the set threshold, action is taken. If the time to depletion is longer than the set threshold the pattern data is updated in a step **262** and the logic flow is repeated the next time a transaction occurs.

It should be understood that although in this described logic flow three determinations are made as to available memory, in other embodiments a lesser number of tests or additional tests may be made. In addition the tests may be correlated or combined using fixed or fuzzy logic type principles to calculate a time when depletion is expected.

In the event that there is concern about lack of memory as determined in steps **248**, **254** or **260** a determination is made at a step **264** concerning whether the instructions associated with the image server include executing an image download sequence prior to the memory reaching capacity. If so an image download sequence is executed at a step **266**. This image download sequence may be to a remote terminal through the network. Alternatively the download sequence may be to a hard or soft permanent or temporary storage device. Such download sequence also includes clearing the portion of the memory that becomes available after data is downloaded or otherwise allowing the memory to be overwritten such that additional image data may be stored. Banking machine data which identifies the particular machine which generated the image and transaction data may be added to or stored in correlated relation with the downloaded data in accordance with programmed instructions to facilitate analysis after the data is downloaded.

If the computer and associated image server is not configured to conduct an image download, a determination is made at a step **268** concerning whether available memory may be reallocated. In some circumstances the memory allocated for storage of images may be expanded to include additional memory. This may include for example a dynamic reallocation of memory storage by the operating system of the machine based on resources being utilized. Such memory may be allocated on a temporary or permanent basis. If memory reallocation functionality is provided a reallocation sequence is executed in a step **270**.

If memory reallocation is not available a determination is made at a step **272** as to whether a notification message concerning impending depletion of the memory has been sent within a given time window. If a message has been sent within the time window then no further action is taken. However if a message has not been sent within a given time window a message is formulated by the image server at a step **274**. This message preferably includes data as to the particular machine and when the available memory will reach depletion based on the current rate of transactions, historical data, threshold value or other basis upon which the determination to send the message was made. After the message is formulated the device server executes the message sequence and operates to send the message to the users who are to receive it based on the image server configuration and the instructions stored in the system. Generally such messages will be sent as one or more e-mail messages to selected e-mail addresses in the network. Of course in alternative embodiments other types of messages may be sent.

FIGS. **26** and **27** show examples of user screens which are presented by the image server to user terminals as part of a configuration sequence. Through use of the templates established through these setup screens users are enabled to configure individual e-mail and group e-mail lists. These lists include persons to be notified in the event that particular events occur. The notification of particular individuals at e-mail addresses is included as part of the timing and sequence instructions stored in connection with the image server which determine what is done in response to particular events.

As later discussed in detail alternative forms of the invention may operate to selectively delete stored image and/or transaction data. For example, transactions may be identified by selected parameters and image and/or transaction data associated with those transactions may be deleted. This may be done based on parameters such as elapsed time since the transaction was executed. Alternatively, transaction data may be deleted based on the type of transaction, amount or other triggering event associated with the image data. Thus, for example, data associated with withdrawal transactions which are under a certain amount and which occurred more than a particular number of days previously, may be deleted in response to programmed instructions. This frees up available space for storing data associated with additional transactions while to preserving image and/or transaction data related to other transactions which may be more significant. Similarly, image or transaction data captured in response to other types of triggering events such as alarms, servicing activities or other conditions which correspond to a particular parameter or combination of parameters may be stored for longer periods of time prior to deletion and/or downloading from a local memory. Various parameters for the preservation or deletion of data may be developed based on the nature of the system, the transactions conducted and the needs of the system operator.

Alternative embodiments of the invention may operate to advise a person who is setting up sequences or operation of the system, about how long the system will be able to run before image data will need to be deleted or off loaded. The computer operating to store data or in connection therewith, may store historical use data for the ATM or other machine. Such historical use data, combined with the number of images that the system is configured to capture and the degrees of associated data compression (as well as possibly other data) may be used to calculate a period of time until the available memory is used. Alternatively, and particularly when no historical use data is present, the computer may be programmed to prompt a user to provide estimates of the number or frequency of triggering events and/or transaction rates. This information may be used by the computer to calculate how long the system can operate without deleting or off-loading images. The user in response to the output of such estimates may choose to change settings or sequences to capture more or fewer images in response to each transaction or event, or to change the degrees of data compression. In addition the computer may be configured to send a message to a selected user or address if transaction rates change from the historical or estimated rates by more than a set amount, and advise of the time period available based

on the actual rate of memory use. In response to such a message a user may choose to reconfigure the system.

The described form of the present invention presents a useful user interface which may be used to set up the system configuration. Generally such configuration is established from a user terminal which is connected to the image server through a network. In this example the image server configuration provides for three levels of activities which users are authorized to perform. These levels correspond to categories of privileges and are "administrator", "operator" and "service". A screen **278** shown in FIG. **16** shows the categories of activities and the user groups which are permitted to perform them in accordance with the configuration of an exemplary embodiment of the invention.

As previously discussed, certain forms of the invention enable the configuration to include timing and sequence data which specifies what images and data to capture, as well as what further actions to take in response to certain triggering events. FIG. **20** shows a screen **280** which may be displayed at a user terminal to establish a sequence of events that occur in connection with particular events. Such sequences may be programmed so that the sequences are different based on the day of the week and/or the time of day.

In accordance with the user interface in this exemplary embodiment, sequences are programmed by establishing a daily schedule of what is to occur in response to events. FIG. **21** shows a screen **282** which is presented in response to clicking on the "daily program" icon from screen **280**. Screen **282** enables a user to configure the program to establish what is to occur if particular events occur within a given time window. In programming of this embodiment, if multiple sequences overlap days, the narrowest schedule overrules broader schedules. For example if a schedule is configured for weekdays but a different schedule is configured for a specific day, the specific day schedule will overrule the general schedule for that day. Likewise to prevent inadvertent overlap of sequences, the programming of this embodiment provides entering only a start time for a sequence. An end time is not required and a sequence will continue until a new sequence is begun. FIG. **22** shows a screen **284** used in an exemplary embodiment of the invention. Screen **284** is generated responsive to selection of the "every day icon" from screen **282**.

Actions in a sequence are established by selecting the "setup sequence" icons shown in screen **284**. Selecting such an icon that is active generates a screen **286** of the type shown in FIG. **23**. Screen **286** enables a user to establish the degree of data compression for images captured during the sequence. The compression level can be modified such that different sequences of events cause images to be captured at different compression levels which produce different image quality levels. Generally the less the data is compressed the higher the image quality. However available memory is used more quickly when the degree of data compression is less.

In this exemplary embodiment of the invention a plurality of actions may be added to a sequence by clicking on icons such as "add camera", "add output" or "add e-mail". In alternative embodiments, additional actions may include "repeat sequence" and "wait" type actions. Clicking on such icons changes the system configuration so the system will take actions in a sequence such as those previously discussed. Such sequences may include for example input of instructions for capturing images from cameras, sending e-mails to individuals or groups of individuals, providing selective outputs to the control devices, or sending messages through the to network. As can be appreciated from screen **280** various sequences may be executed responsive to triggering events such as detection of motion in fields of view of various cameras, the blocking of one or more cameras (at any time or during a time of desired image capture), in response to various transaction functions carried out by transaction function devices or on a periodic time schedule. Screen **288** shown in FIG. **25** is an exemplary screen presented at a user terminal which enables a user to set up the transaction data to be captured as well as to facilitate communication between the image server and the automated banking machine. Of course various types of transaction data can be selectively captured. This is done from screen **288** by selecting types of transaction data to be captured. Image data may also be captured in response to the operation of selected transaction function devices and responsive to the type of transaction function devices resident in the machine.

In the event that the sequence configuration includes sending e-mail messages to selected addresses, the image server is operative to send such messages in accordance with e-mail information which has been stored in connection therewith. Screen **290** shown in FIG. **26** is a template for a user to use in inputting e-mail address information for individuals. Individual e-mail addresses may be combined into e-mail groups and a screen **292** shown in FIG. **27** may be accessed to show the groups of individuals who are notified responsive to events which may occur at the terminal. The configuration of the terminal is such that a plurality of individuals may be sent an e-mail message in response to the occurrence of a single event or other activity at the terminal. This facilitates the notification of individuals in the event that several individuals may be required to respond.

As previously discussed, the timing aspect of programmed sequences enables different individuals to be notified of events at different times and on different days. This facilitates notifying the persons who have the most direct responsibility for the condition at the time it occurs. Forms of the invention may also be configured to attach or include in e-mails, images which correspond to the triggering event which causes the notification to be sent. This may immediately provide the person receiving the e-mail with useful information about what is occurring at the machine. A series of images or applets for the modification of images may also be transmitted with the notification. This may include for example images which occurred prior to the triggering event. Such e-mails may also include information about the nature of the triggering event, the location or banking machine where such event is occurring and other pertinent data. In this way, the entities notified will receive a record of what has or is happening at the machine. This record will also be available even if the machine is compromised and rendered inoperative shortly thereafter. Embodiments of the invention may also include with such image files, digital watermarks or other indicia of authenticity so that the accuracy of the information provided and the images associated therewith have enhanced assurances that they have not been tampered with. Further, included in e-mails or attachments thereto may be sound or other files with which images are associated. This may be accomplished through the programming of sequences which include the capture of audio or other data in response to the occurrence of triggering events. Numerous alternative approaches may be taken utilizing the principles of the invention. Of course, embodiments of the system may carry out communication in ways other than through e-mail such as by RF, fax or simulated voice communication through telephone connection.

As previously mentioned, security associated with the image server may be important to prevent accessing by

unauthorized individuals. In the exemplary form of the invention password protection is provided to minimize the risk of unauthorized use. Of course in other embodiments other security techniques such as public key encryption, encryption of image and transaction data and digital signatures may also be utilized. FIG. 24 shows a screen 294 which is used in embodiments of the invention to establish access for particular users. A system administrator is enabled to gain access to screen 294 and to input information concerning additional users. Screen 294 also enables the system administrator to establish passwords to be used by each authorized user.

Embodiments of the invention may also restrict certain users, or certain categories of users, in the type of image data that may be reviewed. This may be done in exemplary embodiments by limiting access to image and/or transaction data selectively to users, based on the types of triggering events associated with the storage of images. Alternatively, certain users may be precluded from viewing images captured from certain cameras. This capability may be used to prevent certain users from observing certain images such as images which may include customer PINs or the combination to a lock on an ATM. By preventing selected users from accessing certain image data based on the type of triggering event or camera associated therewith, images captured by the system that need not be restricted may be made available more broadly and used for potentially more purposes.

A useful aspect of embodiments of the present invention is the ability of the system to provide screens or displays of image and transaction data that can be readily sorted, viewed and analyzed at user terminals within the network. FIG. 17 discloses a screen or display 296. Display 296 includes sets of images 298, 300, 302 and 304. Each image set includes "thumbnails" of five images. Each set corresponds to a transaction carried out by a particular user and each set of thumbnail images which comprises a set, corresponds to images of the particular user during that transaction. Of course it should be understood that in situations where the timing and sequence programming require a lesser or greater number of images, the number of images which comprise a set may differ. In addition as previously discussed, some transactions or triggering events may have no corresponding images at all. Other events which do not correspond to ATM transactions may have a large number of images spaced closely in time depending on the configuration of the system. This may include full motion or image frequencies approaching full motion.

The images which have been captured and stored by the system may be preferably arranged in one or more series. A series may be a collection of all stored images arranged chronologically. Alternative series may be produced by segregating images that correspond to one or more types of triggering events or transaction parameters. Images included in such a series may be ordered chronologically, may be ordered in a hierarchy in accordance with one or more search parameters, or other ordering scheme. A useful aspect of some embodiments is that the user terminal enables a user to scroll through a series of images, displaying one or more of the images on the display at a time, by selecting certain icons with an input device. The icons enable the user to selectively display images and to move to display one or more different images at points forward or backward in the series from an image or images currently being displayed. In exemplary embodiments, selection of certain icons cause the display to change and display images in different increments and in different directions in the series from one or more images currently displayed.

In an exemplary embodiment screen 296 includes icons 306, 308, 310, 312, 314 and 316. The icons may be used to selectively scroll through sets of images and images in the sets. As explained with reference to an exemplary help screen 318 shown in FIG. 18, selecting icons 310 and 312 enable scrolling backwards and forwards respectively by one event. Selecting icons 308 and 314 enable scrolling backwards and forwards respectively by an increment of ten events. Icons 306 and 316 enable scrolling backward and forward respectively to the beginning or end of a series of events or images.

Exemplary screen 296 also includes "jump to image" and "jump to event" input boxes 320 and 322, respectively. As explained in FIG. 18 boxes 320 and 322 may be used to select images that are to be displayed. A "save comments" box 324 is used to selectively store comments in correlated relation with particular images. Comments can be manually input, input by voice as sound files, input through voice to text conversion software or may be generated and stored in response to programmed instructions based on parameters and/or triggering events.

Screen 326 shown in FIG. 19 shows a selected image 327 which has been enlarged by selecting one of the images from the sets. This may be done in the described embodiment by clicking on an image with a mouse or through other inputs. As shown in screen 326, the enlarged image 327 is displayed with corresponding transaction data which corresponds to the image. In addition event and image data corresponding to the image is also displayed. A user reviewing the image data is enabled to review any of the available image and transaction data.

Advantages of the described embodiments of the present invention include the ability of a user terminal to access image and transaction data selectively. For example through operation of the browser or other programs within the user terminal an authorized user is enabled to search for selected parameters such as user name, account number, time and date and other data which may be stored in the data store. Image and transaction data may also be searched by combinations of parameters or ranges of parameter values. This enables the operator of the user terminal to find selected image data rapidly or more selectively, and without having to scan through large volumes of information. In addition the exemplary forms of the present invention enable holding image and transaction data for substantially longer periods of time with minimum inconvenience. As a result this enables such data to be analyzed for much longer time periods and potentially much more inexpensively than is currently possible.

A further advantage of preferred forms of the present invention is that image data is readily accessible and searchable. This facilitates identification in connection with issued documents such as bank checks or value loaded to smart cards as previously discussed. This enables users having access to the data to verify that a document or other item is being presented by an authorized user by accessing and visually or automatically comparing image data. Further advantages and novel aspects of the invention will be apparent to those having skill in the art.

FIG. 28 shows yet another example of a system of the present invention designated 328. System 328 is similar to other systems of the invention previously described except as discussed herein. In system 328, image capture and delivery functions are performed by a separate device 330. Device 330 in this embodiment includes one or more computers or processors therein including one or more

servers, and is operative to capture and store image data, transaction data and other information from devices to which it is connected. Device 330 also includes appropriate interfaces to communicate with the devices to which it is connected for purposes of receiving inputs and outputs. As schematically indicated in FIG. 28, a computer included in device 330 is in operative connection with a data store for purposes of storing instructions as well as image and transaction data. It should be understood that while a single device for performing the functions is shown in system 328, other forms of the invention may include a plurality of operatively connected devices including a plurality of processors and operatively connected data stores as well as other computers and interfaces, to perform the functions similar to that of device 330 described herein.

In system 328, device 330 is connected to one or more automated banking machines schematically indicated 332. Automated banking machine 332 is similar to the machines previously discussed and includes a plurality of transaction function devices. Automated banking machine 332 may have one or more cameras or other image capture devices adjacent thereto as represented by camera 334. As will be appreciated, a number of cameras may be positioned adjacent to the machine by being within and/or near to automated banking machine 332 for purposes of capturing image data related to users, documents, surroundings or other types of visual inputs that may be desirable to capture and analyze. Camera 334 is operatively connected to device 330 such that device 330 may receive and capture image data therefrom. It should be understood that additional types of data capture devices may also be included adjacent to or within automated banking machine 332. This may include for example microphones for capturing sound or voice information as well as devices which capture data related to transactions. Embodiments of the present invention can use voice recognition software to detect sounds from the microphone representative of words or the stress levels of sounds emanating from persons near the automatic banking machine. Such voice or sound data may be used in combination with images or other data to further detect and evaluate conditions at or near the automated banking machine. The data or information which is captured is also communicated to the device 30 through one or more appropriate electronic connections schematically indicated 336.

In addition to capturing images or other data from one or more automated banking machines, system 328 may also be operative to monitor one or more other transaction devices, as well as to monitor and record activities which occur within a facility. One or more cameras represented by cameras 338, 340 and 342 are shown and are representative of cameras used for this purpose. The cameras may be used for capturing images in response to triggering events, which may be either hard or soft triggers from one or more types of input devices. Alternatively, the cameras may capture images on an ongoing basis in one or more sequences for purposes of providing a generally continuous record of overall activity within an area. As in the previous embodiments, this form of the invention also provides the capability of capturing images from multiple cameras generally simultaneously as well as the capability to both capture images and be delivering messages or image data from the device 330 on a generally simultaneous basis. As will be appreciated, the capabilities of the system may be increased by the addition of components or enhanced capabilities of the components which comprise device 330. This may include, for example, additional interfaces for digitizing image data received from cameras, additional and faster interfaces for input and output devices and increased processing capabilities and data storage to facilitate enhanced function. The required capabilities of device 330 depend on the particular type of system that a user desires to operate and the number and type of connected cameras and other devices.

In the exemplary embodiment shown, a number of different types of input devices are provided. These input devices provide inputs indicative of one or more triggering events to device 330. Such triggering events cause or may affect the manner in which image data is captured by the system. Generally the input devices include appropriate interfaces in connection therewith to enable the device 330 to receive signals indicative of the triggering event. The exemplary input devices shown include a cash register 344. Cash register 344 which may also be considered a banking machine, is connected to device 330 by a communications link such as a local network. This enables the device 330 to cause images to be captured from a corresponding camera when signals indicative of transactions are occurring at the cash register. It should be understood that cash register 344 is representative of but one of numerous types of devices that may be used in a sales, service provider or banking environment and for which it may be desirable to make a record of activity occurring adjacent to such devices when activities are conducted.

Additional representative input devices include sensors schematically indicated 346. Sensors 346 may include sensors for detecting the opening of doors, windows, ventilation ducts or other activities for which it is desired to capture images. Another exemplary input device includes an alarm input 348. The alarm input 348 may be, for example, a device which is actuated by person to indicate an alarm condition. This may be, for example, a panic button which is pressed to indicate a hold-up in a banking or other establishment. Alarm input devices may take various forms and may include sequences input to computer terminals or other devices which are connected to device 330.

Sensors used in connection with the systems may include photosensors, infrared sensors, radiation beams or similar detectors. Such detectors may be used to sense when a person or item passes or occupies a particular space or area. For example, a detector may detect when an invisible beam type sensor is interrupted. Such an invisible beam may extend, for example, across a counter or bank teller window. As a result, a signal may be given to capture images in response to each occurrence of something passing over the counter or through the teller window. Similarly, such a beam may extend across a cash drawer or similar device. Alternatively, such invisible beams may extend in areas known only to an employee of the facility. This may enable the employee to give a signal to capture images (and perhaps activate an alarm) while not making physical contact with any device. Numerous systems may be developed using these principles.

Other input devices schematically indicated 350, may include other devices which detect or receive indications of activity and provide appropriate electrical outputs which can be received by device 330. These may include for example heat sensors, infrared sensors, weight sensing pads, electronic beams or other types of sensors which can detect conditions for which an operator of the system may wish to capture images or other data.

In this embodiment of the invention, the cameras themselves may also serve as input devices. The cameras provide inputs which enable the detection of certain image condi-

tions. Image conditions may include for example, the detection of motion within the field of view of the camera. Alternative image conditions may include a lack of usable video. This may be for example a lack of contrast in an image, brightness or darkness beyond selected limits or other images or circumstances such as previously discussed. Alternatively as previously mentioned, image conditions may include the presence within a field of view of persons with particular clothing or features, the presence of persons with certain body orientations, the presence of certain objects such as weapons or the presence of particular types of colors or arrangements of colors. Numerous types of image conditions which may be determined through analysis of the digital images which are available from the cameras connected to the system may be used as triggering events.

In the embodiment of the invention shown, device **330** is also connected to output devices. Exemplary types of output devices shown include an audible and/or visual alarm schematically indicated **352**. Such an alarm may give persons in an area notice of an alarm condition. An alternative form of an output device as shown may include lighting devices schematically represented **354**. Lighting devices may be turned on for example in response to programmed sequences to illuminate an area where an alarm condition is detected. Other types of output devices may include blocking mechanisms schematically indicated **356**. Blocking mechanisms **356** may operate to block certain areas to prevent access or escape. Alternatively in response to some alarm conditions as set through sequences programmed in device **330**, other alarms may cause blocking mechanisms to open to facilitate escape of persons from selected areas. Other output devices include, for example, communications devices schematically represented **358**. Communications devices **358** may include, for example, police alarms or dial-up devices to notify fire or security agencies of alarm conditions which are detected.

As schematically represented in FIG. **28**, device **330** is connected to a user terminal device **360**. User terminal **360** may be used for providing inputs from users of the system as well as outputs to users, as later discussed in detail. Device **330** is also shown in connection with a network **362**. Network **362** like other networks discussed herein, may be a communications link suitable for communicating, and may be a local network or a plurality of interconnected networks through which device **330** is enabled to communicate through an appropriate interface. Remote terminals **364** and **366** are connected to the network **362**. The remote terminals may be used for providing inputs and outputs to the device **330**. Such terminals may also be used for purposes of programming and receiving images from device **330** in ways which are later discussed. Other terminals in the network may be used to hold data which may be used to identify persons, signatures, documents or provide other functions or information as previously discussed.

It should be understood that system **328** is exemplary of many system configurations that are encompassed within the scope of the present invention. In one exemplary form of the invention, device **330** includes a Diebold AccuTrack™ digital video system which is commercially available from Diebold, Incorporated, the assignee of the present invention. Device **330** operates to provide a helpful user interface for communicating with and programming the system. Such communications may be carried out through the interface at a local terminal such as terminal **360** or remotely from terminals connected to device **330** through a network such as terminals **364** and **366**. FIG. **29** shows an exemplary introductory screen **368** produced on an output device of a user terminal in connection with device **330**. The user terminal, like those previously discussed includes a computer with a browser operating therein, which can communicate with device **330**. Screen **368** provides a useful interface for a user of the system to configure the operation of the system. It also provides a useful interface with which users may interact to recover and sort images that have been captured by the system as well as to carry out other functions.

Screen **368** as well as other screens presented by the exemplary device **330** includes a set of icons and indicators referred to as a tool bar **370**. As shown in greater detail in FIG. **30**, tool bar **370** includes a plurality of icons **372**. Icons **372** include a home icon **374**, a log-off icon **376** and an image search icon **378**. Other icons included in the tool bar include a camera check icon **380**, a system configuration icon **382**, a system tools icon **384** and a help icon **386**. Generally, the icons include an image or representation of an object which suggests to a user the function of each. For example, the log-off icon **376** includes a representation of a key that can be turned. The exemplary form of the search icon **378** is a representation of a pair of binoculars. Similarly, the icon **380** that is selected to conduct a camera check is a visual representation of a camera. Each of the icons **372** and the functions that a user is enabled to accomplish through the selection of each is explained in greater detail in FIG. **31**.

The tool bar **370** includes among icons **372** a status icon referred to as **388** in FIG. **30**. The status icon **388** indicates to a user the status of the system. Several status icons are provided responsive to the then current status of device **330**.

The various status icons presented in the exemplary embodiment are shown in FIG. **32**. For example, a visual representation of a traffic light showing a green light **390** is displayed to indicate that the system is operating to capture images in the normal manner. A representation of a thermometer approaching the top of its range is included in an icon **392**. This icon is displayed to indicate that the storage capacity of the data store within device **330** is reaching its maximum capacity and is not storing images in the usual manner.

An alternative icon **394** is displayed to indicate that there is a need for a user to exercise caution as the system is running with errors. Another icon **396** which is a visual representation of a diskette is displayed to indicate that input changes to the configuration of the device **330** have not been applied. An icon **398** which is a visual representation of a stop sign is displayed to indicate to a user that an application error has occurred or that some other problem has happened such that the system is not operating or communicating normally.

In this exemplary embodiment, a user at a terminal is enabled to program or configure operational features of the device **330**. Preferably a user will be enabled to configure many features and operations of the system. This is accomplished in the exemplary embodiment by the user making selections and inputs from screens or pages in a graphical user interface through which a user sets up or changes the programming of the system. These interface screens and pages are displayed to the user responsive to selection of icons in the tool bar and through subsequent selections as a user operates the automated banking machine in response to the interface.

In the exemplary embodiment, one of the aspects of the system that a user is enabled to configure is the period of time that image data and other data including transaction data is stored. In this exemplary embodiment, the device **330** is configured to store data for at least certain programmed

periods of time prior to deletion. FIG. 33 shows an exemplary screen 400 which is presented to a user of the system. Screen 400 includes image type categories 402. The image type categories correspond to the types of triggering events which caused an image to be captured. For example, in FIG. 33 the types of images corresponding to "normal" are those images that are captured in response to programmed sequences which are done periodically on a routine basis such as for a periodic surveillance of an area. Those image types which are captured in response to alarms correspond for example to images captured in response to trigger inputs such as a panic alarm or an intrusion into a secure area within a facility. Other image types correspond to transactions. These may include for example in the exemplary embodiment transactions conducted at automated banking machine 332 or at cash register 344. Through inputs in response to screen 400 a user is enabled to input and select which types of images are to be deleted first and last. The user is also enabled to set up minimum periods during which images corresponding to particular image types are to be retained.

FIG. 34 shows an expanded screen 404 which further enables a user to configure the auto deletion feature of the invention. Through inputs in response to screen 404 a user is enabled to set the unit to accomplish automatic deletion of images in accordance with the parameters that have been input. The user is further enabled to input when the auto deletion activity is to begin as well as when available disk space is considered sufficient such that auto deletions should stop. As a result in response to the user selecting to have auto deletion activity occur, the device 330 will operate to selectively begin deleting images in accordance with the priorities that have been established for the retention of images so that additional storage space may be made automatically available.

It should be understood that the parameters and deletion capabilities shown in connection with screens 400 and 404 are exemplary and other embodiments of the invention may operate to store image data and delete it selectively in response to other parameters. In addition, the auto deletion function may be combined or integrated with an automated downloading function so as to selectively transfer images prior to deletion to another storage area that is connected to device 330. This may include, for example, the transfer image and transaction data to other terminals connected in network 362 so that such image data may be stored at a remote location prior to deletion of the image data from the device 330. Other approaches and techniques appropriate for systems of the invention will be apparent to those skilled in the art from the foregoing description.

Another aspect of the exemplary embodiment that may be configured by an authorized user is the security applied to various types of images. In the exemplary embodiment device 330 allows a user to selectively apply authenticating algorithms to selected types of images. A screen presented to a user in the course of configuring the system to establish this capability is represented 406 in FIG. 35. In response to screen 406, a user is enabled to set the system so that digital signatures are applied to any of several different image types. For example as represented in screen 406, a user may elect to include digital signatures in images captured in response to triggering events such as alarm conditions, detection of motion or other hard trigger alarms. Likewise as shown in screen 406, the user may configure the system to apply digital signatures into images captured in response to transactions conducted at an automated banking machine. In the particular example, shown in FIG. 35, digital signatures are not applied to "normal" images which are those captured in response to routine periodic sequences. As represented in screen 406, the user may also elect to apply digital signal security to no images or all of the images captured in the operation of the system. It should be understood that the categories of images shown in screen 406 are exemplary and in other embodiments other types of image parameters may be used.

A further useful aspect of the exemplary embodiment of device 330 and the system 328 represented in FIG. 28 is the ability of an authorized user of device 330 to program sequences in which images or other information are captured. As is the case in embodiments previously discussed, sequences include a triggering event and a series of actions that are taken by the system in response to a triggering event. Triggering events may include, for example, sensing image conditions such as motion, lack of usable video or a blocked camera and taking a series of actions in response thereto such as capturing images from other cameras, turning on lights, placing in permanent storage temporary image data that was captured prior to the triggering event, sending messages such as e-mails or performing other actions. Similarly, triggering events may include activities conducted at an automated banking machine or other transaction machine, during which times it is desirable to capture and permanently retain images from cameras which have a field of view that includes the area where the machine is positioned. Similarly triggering events may include inputs to or from alarms or sensors. Other triggering events may include sequences which operate on a timed or other periodic basis in a routine manner such that image data is stored in relatively permanent storage from each of the cameras in the system as a routine matter of course. Numerous types of sequences can be programmed by an authorized user using the exemplary embodiment of the invention.

For purposes of the particular exemplary embodiment of system 328, triggering events are cataloged by type as either "normal", "alarms" or "transactions". Normal images are those that are captured in accordance with routine sequences that are carried out on a periodic basis in accordance with the programming of device 330. Different routine sequences may be operative at different dates and times in accordance with the system configuration. Such routine sequences may, for example, capture an image from a particular camera so as to store it in relatively permanent memory every so often, then subsequently capture an image from another camera and so on. Because these "normal" images are captured on an ongoing basis, care is generally exercised by the operator of the system to be sure that not so many images are stored that the available storage space is occupied too quickly by images that are of no particular interest.

The images classified as "alarms" are those that correspond to alarm type inputs. These can include hard trigger alarms such as those provided by switches, invisible beams and buttons that may be tripped as activities occur. Similarly, the category of "alarms" include image conditions such as motion detection, loss of usable video, detection of particular features, clothing, body orientation, colors or objects within the field of view (or a detection area smaller than an overall field of view) of a particular camera. Each alarm sequence may include appropriate actions such as actuating lights, blocking devices, alarms, contacting police or fire departments and/or sending e-mail messages and/or images to predetermined addresses.

In the exemplary embodiment, images associated with "transactions" are images associated with devices at which transactions are carried out. These may include transactions

conducted at automated banking machine 332, cash register 344 or other devices where it is desirable to make a record of the transactions. With regard to transaction images the sequence typically involves a triggering event related to operation of a component of a transaction function device or terminal, and the actions may include capturing the image to store it in memory and perhaps additional steps depending on the nature of the transaction being conducted. Again, it should be remembered that the categories of triggering events in this embodiment are exemplary and other triggering event categories may be used in embodiments of the invention.

In the exemplary embodiment, device 330 operates in a manner like that previously discussed to digitize image data received from all or a selection of cameras on an ongoing basis. This image data is digitized as image frames on an ongoing basis and remains stored in the memory associated with the computer of device 330 for a fairly limited period of time. These temporarily captured and stored images may be more permanently captured by being moved to relatively permanent storage at the time that they are received or alternatively may be moved into relatively permanent storage at any time prior to their deletion. The value in digitizing and temporarily capturing images on an ongoing basis as often as possible from selected cameras include the ability to recover image data from a time prior to a triggering event. Thus for example if an image condition such as a blocked camera is detected, one or more prior images from the same camera that are still in temporary storage may be transferred in response to the triggering event to more permanent storage and correlated with data representing the triggering event. This may enable detection of an image which includes a person who caused a camera to be blocked. The ability to retain on a more permanent basis images which occurred prior to a triggering event is configurable in the system, as are the number of images prior to the triggering event which may be transferred to more permanent storage. Of course the ability to transfer prior images depends on the number of image frames that are available in temporary computer storage from each camera prior to the deletion of such images. Of course the duration that such temporary images are stored can be increased with the addition of additional storage and processing capability. Likewise, the frequency of these temporary images from any given camera depends on the processing capabilities of the computer operating in device 330. Faster processing may similarly increase the frequency at which temporary images are captured.

A useful aspect of the exemplary embodiment includes the ability to program sequences using descriptive terminology which is established by a user of the system. FIG. 36 shows a screen 408 that is displayed to a user in configuring system 328. Screen 408 is a camera set-up screen in which a user is enabled to give descriptive names to the particular cameras or field of view of a camera connected to the system. From screen 408, a user is enabled to select a camera through use of an input device such as a mouse and to "see" the field of view that is associated therewith. The user is also enabled to input a descriptive name for that field of view such as is shown in connection with "camera 01" shown in FIG. 36. As subsequently explained in detail, a user is enabled to configure sequences including triggering events and actions to be taken in response thereto using the descriptive names that the user has given to various cameras in the system. This capability greatly simplifies the programming of the system as users are not required to learn any special conventions or terminology.

As is the case with cameras, users are also enabled to apply descriptive names to outputs which are provided from the device 330. These outputs may include for example a descriptive name for the particular item or action which is triggered by the output. For example, in FIG. 37 there is shown a screen 410 in which an authorized user of the system is presented with output numbers for the various contacts and connections that may be made to device 330. By making an appropriate selection and input, the user is enabled to apply descriptive terminology to these outputs. For example, in screen 410 "output 01" has been named to indicate that it operates to turn on lights in a vestibule. Of course this is exemplary and any appropriate name may be input in the discretion of the operator.

Similarly, the user of the system is enabled to provide descriptive names for the inputs which serve as triggers for executing sequences by device 330. Screen 412 in FIG. 38 shows the capability of a user to give a descriptive name to a particular input device. For example, in FIG. 38 "input 01" to device 330 is indicated as associated with a teller panic button. Having this descriptive information available and usable to program sequences in the invention makes it much easier for a user to set up and check that the desired activity is happening in response to a triggering event in any given sequence.

FIG. 39 also shows the capability of device 330 to execute sequences that are triggered by operation of automated banking machine 332. A screen 414 in FIG. 39 shows an ATM monitoring set-up screen. In response to the presentation of screen 414, a user is enabled to give the automated banking machine a particular descriptive name. This descriptive name may include the particular street address where the automated banking machine is located. Similarly, if there are several automated banking machines at the same address, each machine may be assigned a descriptive name representative of its location. Such terms used may include names such as "lobby ATM", "drive-through ATM" and "walk-up vestibule ATM". Of course many other types of names and designations may be used depending on the particular type of automated banking machine involved.

In the exemplary embodiment of screen 414 shown in FIG. 39, the system 330 is shown configured to operate in connection with an ExpressBus™ interface which is used in automated teller machines manufactured by Diebold, Incorporated, the assignee of the present invention. Of course in other embodiments of the invention other appropriate set-up screens suitable for configuring the programming of the system to work with other types of machines may be presented.

As was discussed in connection with other embodiments, actions performed as part of a sequence may include sending e-mails to one or several persons notifying them of the occurrence of the triggering event. Screen 416 shown in FIG. 40 may be used by an authorized user of the system to input e-mail addresses that are to be notified of triggering events. Further as represented in screen 416, a user is able to designate groups of persons who are to be notified of particular events. These descriptive names for groups enable an authorized user to readily configure the system so that a number of people receive an e-mail message notifying them of a triggering event. Such actions are readily programmed into a sequence by referring to the name of the group.

Screen 418 shown in FIG. 41 shows an example of an e-mail group which has been named "security". This would be, for example, a group of persons or entities that are to be notified in the event that a triggering event detected by the system indicates a breach of security or some activity that should be investigated by a security organization responsible

for the facility. As can be appreciated by screen **418**, an authorized user of device **330** is enabled to add, delete and edit e-mail addresses which compromise the groups which are to be notified.

The exemplary embodiment of device **330** enables an authorized user to readily program the system to carry out various types of sequences. These sequences include sequences associated with the capture of "normal" or routine images that are stored on a timed or other periodic basis while the system is operating. The user is also enabled to program sequences in response to the various types of triggering events such as inputs, motion detection, lack of usable video and the conduct of transactions. FIG. **42** shows a screen **420** which is presented to a user in connection with establishing routine sequences for the capture of images and storage on a relatively permanent basis. Screen **420** also shows the beginning point for the programming of sequences in response to input devices which will be later discussed in detail.

In response to user selection of the "daily program" box in screen **420** a screen **422** shown in FIG. **3** is presented. Screen **422** shows a visual representation of a weekly layout for hours in each day and the names of programs or sequences which are operated to capture routine or "normal" images during the indicated times. In addition to viewing the sequences that are operative at various times during the week from screen **422**, the user is enabled to view the sequences applicable during any selected day of the week or in groups of days such as by weekdays or weekends. In the exemplary programming of the system, sequences are configured to continue until a time when another sequence is to be initiated. Further, the programming is set up so that a more specific program for a given time period will override a more general program during the selected period.

By selecting a particular day of the week from screen **422**, the exemplary embodiment of device **330** is operative to display to a user a screen **424** shown in FIG. **44**. This screen shows for the selected day the sequences for the routine capture of images that occur on that day and the time periods when each sequence starts and ends. A graphical indication is also provided so that the user may readily see the times during the selected day when particular sequences are operative.

From screen **424**, a user is enabled to select to view any of the selected sequences. For example, by selecting to view sequence indicated "1" in screen **424** the device **330** causes the screen **426** shown in FIG. **45** to be displayed. Screen **426** indicates to the user a graphical representation of the steps involved in the routine sequence. Screen **426** also indicates the data compression level that is to be applied to the images that are captured and stored on a relatively permanent basis. By selecting the compression level the user may choose to have lower quality images in exchange for utilizing less of the available data storage space with images corresponding to the particular sequence. Various levels of data compression are selectable by the user for the sequence as shown in screen **426**.

As represented in screen **426**, the user is also enabled to set an image capture rate which controls the frequency of image capture and storage during time periods which are indicated in the sequence as periods during which images are to be captured by a particular camera. In the exemplary embodiment, the user has the option to capture a certain number of images or to set the system to capture images for a period of time. If the user configures the system to capture images based on time, the indicated rate reflects the number of images captured and stored in relatively permanent memory during each second. The exemplary embodiment also enables a user to select AVI which is an image capture rate sufficiently high such that it appears to capture full continuous motion in a manner similar to a video clip. In the exemplary embodiment the capture of ten or more images each second corresponds to what generally appears to a user to be full motion. Of course, higher rates of image capture may be used.

Screen **426** represents the sequence which is carried out routinely by the system on an ongoing basis using the passage of time as the triggering event for each sequence. As can be seen, the particular cameras in the exemplary sequence are shown by the numbers as well as the descriptive names which have been applied by a user thereto. In this exemplary sequence, a camera which views a front door takes one image every second for three seconds. Thereafter, a camera which takes pictures of an outside ATM takes one image every second for three seconds. After that, a camera which views the back door takes one image every second for three seconds. After completing the sequence, the sequence repeats. An authorized user is enabled to modify the sequence by changing the number and timing of images in the sequence. The user is also enabled to delete and modify steps in the sequence by selecting the "buttons" at the bottom of screen **426**. For example, a user is enabled to selectively or completely delete steps in the sequence, add cameras, add steps and save the revised sequence. Of course in other embodiments additional options for steps or actions in sequences may be provided.

In the exemplary embodiment of the routine sequences, provisions are not made for notifying a remote location via e-mail. This is because routine sequences are continuously executed gathering and storing images at all times while the system is operating. This includes times in which images are being captured in response to other events. In other embodiments however, the system could include as part of the capture of normal images, provisions for providing periodic reports via e-mail or otherwise, to functions or individuals who need to know that the system is operating normally. In addition, such messages may also include one or more images enabling the person receiving the message to visually verify the current condition in the area or facility monitored by the system.

FIG. **46** shows a screen **428** at which a user is enabled to review sequences associated with inputs that correspond to triggering events. Such triggering events may include, for example, the inputs from various sensors sensing activity in various areas under surveillance, inputs from panic buttons or other types of inputs. By providing inputs in response to screen **428** an authorized user is enabled to selectively enable execution of the sequences in response to the triggering events which cause the listed inputs.

By providing inputs to screen **428** a user is enabled to configure the sequences associated with particular inputs. This includes establishing a schedule during which a selected input will cause a selected sequence to be executed. The schedule for the execution of a particular sequence is shown in screen **430** in FIG. **47**. Through inputs to screen **430**, the user is enabled to indicate the time periods during which the system will execute the sequence if the input is received. For example, if the particular input is associated with opening a door, it may not be desirable to capture images during the time periods when the door is frequently opened by employees or customers who access a facility. The configuration associated with the input enables the input to cause the execution of the sequence only at the times

when the capture of images is likely to yield useful information. In the exemplary screen 430 shown in FIG. 47 an input number 2 is configured to cause its corresponding sequence to be executed only between 9 a.m. and 4 p.m. Through inputs to screen 430, an authorized user is enabled to modify these time periods as well as to select separate discrete times periods during which the input will cause the sequence to be executed.

The user is also enabled to set up or modify the sequence that is associated with the input. This is accomplished from screen 430 by an appropriate input that causes the screen 432 shown in FIG. 48 to be displayed. Screen 432 includes a description of the particular event which is associated with the input. Also as is the case with the routine sequences previously discussed, a user is enabled to set the image quality of the images captured and stored in response to the triggering event. Further in the exemplary embodiment, an authorized user is enabled to set the number of times that the sequence will be executed in response to the triggering event. As previously discussed screen 42 also includes provisions for the user to set the image capture rate associated with the capture of images that are done in the corresponding sequence on a timed basis.

The user is enabled to set up a sequence by selecting the "buttons" at the bottom of screen 432. These buttons correspond to various actions related to cameras, outputs and e-mails that the system is enabled to capture images from, provide and send, respectively. In response to selecting one of these buttons, a particular configuration step or action which a user may populate with instructions by making selections therein is included in the sequence. For example, in response to selecting a "camera" button a sequence frame designated 434 in screen 432 is displayed. The sequence frame includes five areas for inputs that can be provided by the user. This includes the camera selection, the number of images, the frequency of the images and the duration or number of images involved. By populating these five spaces in the image frame with data the user is enabled to provide the necessary programming information for carrying out an action in a manner that is readily understood in a sentence format. For example, as shown in screen 432, sequence frame 434 indicates that the camera designated "drive-thru #2" takes one image every one second for two seconds. Of course by making selections and inputs the user is enabled to change the five input areas within the sequence frame to suit their particular requirements.

Similarly, as represented in screen 432 selection of the "output" button enables a user to include a sequence frame 436 in an action the sequence. The sequence frame includes three inputs that can be made by a user to select the nature of the output that is to be included as an action in the sequence. In the case of sequence frame 436 the user is shown as having populated the information for causing the "W station #2 light" to turn on for ten seconds. Thus again the sequence frame enables the user to provide in a sentence format those instructions which correspond to a selected output. Further the outputs are enabled to be selected in accordance with the descriptive names that have been applied to the outputs by a user.

As can be appreciated from screen 432 numerous action steps can be selectively added or deleted from a given sequence as desired by the user in response to the triggering event. It should further be understood that similar sequence frames are provided for e-mails which is a selected action step that can be taken in response to a triggering event. Further in other embodiments additional types of steps can be taken, each of which may have its own sequence frame which a user may populate with particular data to accomplish the carrying out of a particular action step. For example, additional actions may include repeating one or more steps in a sequence one or more times, and waiting for other actions or delaying for a time before taking further actions. Similar principles are carried out in connection with the programming of the various types of sequences by the system of the exemplary embodiment.

FIG. 49 shows a screen 438 which is associated with establishing a sequence in response to the detection of motion in the exemplary system. The motion set-up sequences enable a user to establish when detected motion within a particular area causes images to be captured and stored on a relatively permanent basis, and other actions to be taken as part of a sequence.

In screen 438, the cameras which are included in the system are presented using the descriptive naming terminology applied by a user. In response to the motion set-up screen 428 a user is enabled to select which sequences are enabled or disabled for particular cameras. In addition a user is enabled to access other screens for purposes of setting up selected detection areas in which motion is to be detected, as well as to configure the sequences that are executed in response to motion detection.

In response to selecting a set-up button for an appropriate camera from screen 438, a setup screen showing a field of view currently obtained from the camera selected is displayed at the user terminal. An example of such a set-up screen is indicated for 440 in FIG. 50.

Screen 440 includes a field of view of the designated camera generally indicated 442. The field of view of the camera includes the entire image field that the camera is currently viewing. Through use of a mouse or other input device, a user is selectively enabled to select one or more detection areas schematically indicated 444 within the field of view 442. The detection areas 444 are one or more areas to be analyzed and in which a determination concerning the detection of motion is to he made. An advantage of providing a selected detection area for purposes of determining the presence of motion is that it avoids problems associated with monitoring in areas where motion may commonly be occurring in some areas, but where in other areas the occurrence of motion is an event for which images should be captured. In the exemplary embodiment the system is operative to compare the images only within the selected detection areas on an ongoing basis between the temporary captured images that are stored temporarily from each of the cameras. Comparison of the image in one or more successive ones of these temporary images are preferably analyzed through operation of the computer for differences. In this embodiment the computer operates to analyze the pixels which make up these images for a degree of change. If more than a set degree of change between one or more of these images which are spaced in time is detected, this is an image condition indicative and motion and a triggering event which causes the corresponding sequence to be executed.

An advantage of the exemplary embodiment shown in connection with screen 440 is that the user is enabled to selectively set the degree of change in the image in the detection area which will result in a determination that motion has been sensed. Specifically in the exemplary embodiment the user is enabled to selectively input values as to a percent of sensitivity which corresponds to a change in property such as intensity or color (or a combination of both) among pixels in the detection area that will be considered for purposes of determining whether motion has occurred. Like-

wise the user is enabled to set the percent of activity which corresponds to a quantity such as a number or percentage of pixels subject to analysis experiencing the set change in intensity or sensitivity which is indicative of motion. In this way the user of the system is enabled to set the motion detection parameters for the degree of change which will cause a triggering event indicative of motion detection. A user may thereby avoid motion from being considered detected in circumstances where it is not desirable to capture images.

An exemplary embodiment of the invention includes a service program which enables a servicer or authorized user to test the suitability of the motion detection settings in particular circumstances. This program runs in one or more computers operatively connected to the camera of interest. The user inputs into the computer running the program the selected sensitivity and activity settings. The user may then cause activity to occur in the field of view of the camera. The program then causes a display to operate so as to indicate whether the activity resulted in motion being considered to have been detected. In this way a user may adjust the settings to suit their requirements. Alternatively the system may be operated in a test mode to capture a series of images from a selected camera. The settings may be applied by a test program to these captured images in a controlled manner to evaluate the settings versus the nature of image change. In an exemplary embodiment, captured images may be compared in the sequence originally captured or may be compared in a different sequence to determine the appropriate motion detection settings. Once selected, the selected settings for sensitivity and activity may be set in the system and applied on an ongoing basis.

Returning to the discussion of FIG. **50**, from screen **440** a user is enabled to display a schedule for selected days in which motion is to be detected. This is represented in screen **446** which is shown in FIG. **51**. Through inputs responsive to screen **446** the user is enabled to set the periods during which motion detection is accomplished for purposes of carrying out a sequence. As can be appreciated in many circumstances there are particular times of day during which motion is likely to be going on in a particular area and other times during which the detection of motion may represent an usual event for which images should be captured. Through inputs of screen **446** an authorized user is enabled to selectively set the times during which motion detection analysis will be conducted.

From screen **446** a user is enabled to set the sequence that is carried out in response to a motion detection event. This is done in response to a screen **448** shown in FIG. **52**. Screen **448** includes the ability of a user to set the parameters associated with the detection of motion using the descriptive names for cameras which were set-up by the user. The user is also enabled to set the image quality parameters for the storage of images. In addition to parameters associated with other screens, in screen **448** the user is also enabled to set the number of images captured prior to the detection of motion which will be moved from temporary storage into relatively permanent storage in connection with images captured in response to the motion event. Using inputs directed to the "buttons" in screen **448**, the user is also enabled to set up the sequence frames associated with cameras, outputs and e-mails by populating the information in the frame. A sequence frame enables the user to program using a sentence type structure, the actions which will occur in response to the triggering event. For example, in the sequence shown in **448** in response to motion being detected at the camera which watches the back door of a particular facility, the back door camera takes two images every second for sixty seconds. Thereafter the outside back light turns on for five seconds. In addition to capturing the images from the back door camera, two pre-alarm images are transferred from temporary storage into relatively permanent storage with data which describes the triggering event. Of course, it should be understood that the sequence parameters and actions are exemplary and in other embodiments other approaches may be used.

Embodiments of the invention also capture images in response to triggering events which are indicative of cameras being blocked. Such blocked camera events which are alternatively referred to herein as a lack of usable video, generally result from an image condition in which the image presented is either unduly light or dark, or otherwise lacking in contrast, not changing or otherwise appearing so as to suggest that usable video data is not being received. The sequence as associated with blocked cameras is configured in the exemplary embodiment with inputs responsive to a screen **450** shown in FIG. **53**. In response to presentation of the screen **450** a user is enabled to select the particular camera at which a blocked camera event will be detected.

In response to the user selecting a camera in response to screen **450**, the exemplary embodiment displays a screen **452** shown in FIG. **54**. Through selections made in response to the presentation of screen **452** the user is enabled to set the blocked camera capability as either operative or inoperative. The user is also enabled to set up the criteria used for identifying a blocked camera as a triggering event and to configure the sequence that will be executed in response to the blocked camera event.

In response to a user selecting the set-up button from screen **452**, the exemplary embodiment is operative to display a screen **454** shown in FIG. **55**. In screen **454** the user is enabled to set a brightness intensity (which may represent a color level tending toward white) as well as a darkness intensity (which may represent a color tending toward black). In this exemplary embodiment if the pixels which make up the field of view of a selected camera average above the selected brightness intensity, or alternatively average below the selected darkness intensity, a triggering event indicative of lack of usable video is initiated. Alternative embodiments may look for every pixel being above or below certain thresholds. Alternatively in other embodiments of the invention the pixels which make up the field of view are analyzed by the computer on an ongoing basis for color level or contrast with pixels in other areas of the field of view. A failure of the image to have contrast above a set level for the overall field of view may in addition represent a triggering event indicative of lack of usable video. Of course, as previously discussed, other criteria may also be used for deciding that there is a lack of usable video.

Screen **456** shown in FIG. **56** is presented to a user in the exemplary embodiment to set a time period during which the sequence will be carried out if a camera is blocked. The user is enabled to set the inputs for those times of day during which a blocked camera event will be considered a triggering event for the sequence to be carried out.

FIG. **458** shown in FIG. **57** is displayed in the exemplary embodiment to a user to configure the sequence that is executed in response to a blocked camera event. As in the other sequence configuration screens of the exemplary embodiment, a user is enabled to set the quality of the image data that is captured in response to the triggering event. Further the selection of "buttons" in the lower portion of the

screen **458** causes sequence frames to be displayed which the user is enabled to arrange and populate with data to configure the sequence. As shown in FIG. **58** the sequence frame **460** associated with sending e-mails is displayed. This sequence frame enables a user to input data identifying persons or groups of persons to which e-mails are to be sent. The ability to use the descriptive naming terminology defined by the user simplifies the programming of the sequences in the exemplary embodiment. Further as shown in screen **458** the user is enabled to employ other sequence frames such as sequence frame **462** which is associated with a camera. By populating the inputs for the camera sequence frame the user creates a sequence which is carried out in response to the indicated camera being blocked. The exemplary sequence includes sending an e-mail to the e-mail group that is designated "security". In addition to sending the e-mail, camera #**2** is operated by the computer to capture and store two images every second for twenty seconds. Of course it should be understood that camera number two is a camera which preferably includes in its field of view the camera that is indicated as blocked. Of course as previously explained in other embodiments, the programming for lack of usable video may also include the retention in more permanent memory of temporary images which were taken by the blocked camera prior to the lack of usable video being detected. Such images may indicate the cause of the lack of usable video. Of course other approaches may be used in embodiments of the invention.

In the exemplary embodiment of the invention device **330** is also configured to execute sequences in response to triggering events such as transaction steps which occur at automated banking machine **332** or cash register **344**. In the exemplary embodiment sequences are configured to acquire images in response to the operation of transaction function devices. The images are stored in connection with transaction data regarding the transaction that is conducted at the machine. FIG. **58** shows an exemplary screen **464** which is displayed to an authorized user by device **330** in connection with configuring sequences responsive to the operation of an automated banking machine. Through inputs in response to screen **464** a user is enabled to set up and configure the sequences associated with operation of the machine.

In the exemplary embodiment of the invention inputs responsive to screen **464** enable the user to set up the acquisition of images from particular automated banking machines. This is done through inputs to the user terminal in response to a screen such as screen **414** shown in FIG. **39**. Further from screen **464** a user is enabled to configure the parameters for the acquisition of images in connection with particular events carried out at the ATM. This is accomplished in the exemplary embodiments through inputs through a screen **466** shown in FIG. **59**. Screen **466** enables a user to select triggering events for the capture of images. For example in the exemplary screen shown, the triggering events include the reading of a user's card and the printing of a receipt. The user is also enabled to configure the system to set the quality of the images stored based on the level of data compression used. Further as represented in screen **466**, the user is also enabled to set sequences which include sequence frames for cameras, outputs and e-mails responsive to triggering events which occur in the course of a transaction. For example in exemplary embodiments of the invention the system may capture one or more images of a customer operating the banking machine so as to provide verification at a later date as to the identity of the particular person who has operated the machine to carry out the transaction. The number and character of images may be varied depending on transaction parameters including the transaction type, the time of day, the amount of money involved or other parameters associated with the user.

In the exemplary embodiment of the invention, transaction data is also stored in correlated relation with the captured image data. The image data is correlated with the transaction data by the particular time at which the transaction is conducted. Of course in other embodiments other approaches to correlating image and transaction data may be used. Alternatively, image and transaction data may be stored together in common files depending on the requirements of the system. Generally, in the case of a system monitoring an automated banking machine, the transaction data that is stored will include parameters such as time, user name, account number, transaction type and amount. The storage of these parameters in connection with the images enable the selective sorting of images by transaction parameters. This enables an operator of the system to more readily recover types or ranges of transactions that may of interest. In addition, it facilitates the selective retention or deletion of transactions in some embodiments by factors such as the transaction type and/or amount. Of course, in other embodiments other approaches may be used.

It should be understood that although in the exemplary embodiment image capture from an automated banking machine is conducted responsive to signals sent to transaction function devices on the system bus of the ATM, in other embodiments other triggering events may be used. For example, in embodiments of the invention the presence of a user adjacent to a transaction terminal may be sensed with a proximity sensor such as an ultrasonic detector or a weight sensing pad. Alternatively, automated banking machines may provide hard sensor inputs such as are obtained when a user receives cash from a cash receipt dispenser, or another device on the machine is moved. Such inputs may be configured as inputs to device **330** much in the manner of sensors **346**. Such inputs may be used for purposes of configuring sequences in response to such inputs. For example a screen **468** shown in FIG. **60** represents an example where an input from a sensor is used as the basis for configuring a sequence. Such an input may correspond to the operation of the device on an automated banking machine or other transaction terminal. Through inputs responsive to screen **468** a user is enabled to configure a sequence including capturing images from cameras, providing outputs or sending e-mails in response to such inputs. Of course, numerous other alternatives for accomplishing similar functions are encompassed within the scope of the present invention.

As previously discussed, a useful aspect of this form of the present invention is the ability to conduct searches for images that have been stored. Searches may be made based on one or more parameters. Image searching is accomplished responsive to selecting the icon **378** in the tool bar **370** displayed on numerous screens in the exemplary embodiment. A screen **470** shown in FIG. **61** is used for obtaining user inputs concerning exemplary parameters that are employed in the searching of images. As can be seen in screen **470** a user is enabled to select time periods during which images are to be searched. The user is also enabled to select cameras which captured the image data which will be searched. The user is enabled to select all cameras or particular cameras which are to be searched. Alternatively, a user is enabled to select a "quick viewer option" which enables a user to scan through images in a manner that is later described.

Screen **470** also enables a user to select parameters for identifying images. These include for example selecting

among images captured in response to particular alarm types as well as images captured in response to particular transaction types. In this way a user is enabled to selectively search the images for a number of different parameters. The ability to search by various parameters greatly reduces the effort required to identify images that may fit a user's search criteria.

As explained in connection with other embodiments, image data may in addition be searched by visual characteristics. These may include for example searches for physical characteristics of persons shown in the images. Similarly searches may be made for certain types of apparel, certain colors or certain devices or items. The capability of the embodiments of the present invention may enable identifying particular persons or situations for which available data is otherwise incomplete. This may include for example identifying witnesses or other persons present when particular circumstances have arisen. Of course numerous different types of criteria and parameters may be used in searching for selected images.

A further aspect of the exemplary embodiment represented in screen 470 is the ability to also group images by the particular type of event which has caused the images to be captured. This provides the capabilities of allowing a person reviewing images to catalogue and review images by the triggering event which caused them to be captured together. This may provide a user with additional insights as to particular events. It may also enable a user to search an event type of most interest first before moving onto other images which meet search criteria.

In response to the conduct of searches, various image pages are displayed by the device 330. Examples of image pages are shown in FIGS. 62 through 72. Each of these image pages shows one or more images that have been captured and stored, and which are displayed in response to search requests. The nature of each of the image pages and how they are used in the exemplary embodiment are explained in detail in the charts shown in FIGS. 73 and 74. Of course it should be understood that in other embodiments of the invention other image pages may be used.

It should be noted that in the exemplary embodiment of the invention, a control panel schematically indicated 472 is displayed in connection with image pages. A control panel 472 enables a user to perform various functions to review images, as well as to download images from device 330 to other terminals in the system with a greater degree of assurance that the images have not been tampered with. It should also be noted that in image pages of the exemplary embodiment a graphical representation of a piece of movie film is included to represent to a user that a series of images were acquired at high frequency in response to an event so as to acquire a film clip that approximates full motion video.

A further aspect of the present invention that is useful is the ability of the system to indicate that a plurality of images have been captured in response to certain triggering events. This is indicated by the image sets as represented for example in FIGS. 64 and 65. Further as represented for example in FIGS. 67 through 70, particular images may be selected for enlargement for review by a user with information concerning the nature of the triggering event which resulted in the capture of the image. A listing of the data which is included with triggering events and which can be recovered by an authorized user of the system is listed in the chart in FIG. 75. A further useful feature of the exemplary embodiment is the capability of a user to provide comments concerning particular images. Such comments may be input from the user terminal via typed input in text form. In alternative embodiments, a user may input comments by voice to text conversion input as well as to have comments stored as a voice file. Such comments may be useful later in recovering images when searching by particular comment criteria. The computer may itself be programmed to add comments to particular fields in connection with images depending on the programming of the system.

The control panel 472 used in the exemplary embodiment is shown in greater detail in FIGS. 76 through 80. The control panel 472 includes a plurality of icons and indicators as well as an image counter which is shown in FIG. 77. The function executed in response to selection of each of the icons in the control panel when particular image pages are being displayed is shown in detail in FIGS. 78 through 80. As will be understood from the detailed description, the control panel 472 enables a user to navigate through images in a rapid and selective manner. The user is also enabled to navigate through a series of images sequentially in varied increments and directions within the series of selected or displayed images. Further as represented in FIG. 80, the user is enabled to provide inputs to the control panel so as to identify images captured within certain time parameters. It should be understood that in embodiments of the invention the series of images may be considered to be one dimensional. However in other embodiments the images may be arranged in a matrix or other multilayer or multidimension format based on varied parameters. By making selections and inputs users may navigate in varied directions in the series of images.

FIGS. 81 through 83 show numerical examples of the capability of the control panel 472 in enabling a user to navigate through a series of images which are displayed to a user. As represented graphically in each of these figures the selection by the user enables the user to find an image of interest to enlarge it, mark it and to print those images which are of interest.

A further useful aspect of the exemplary embodiment of the invention is the ability of a user to identify selected images for downloading from device 330 to another terminal which is connected thereto. Such downloading may be accomplished in a manner which provides greater assurance that the downloaded images are not altered. This is accomplished in the exemplary embodiment using a feature which is referred to as an image cart. In reviewing images, a user is enabled to click on a rectangular icon adjacent to images so as to change the color thereof. As represented in FIG. 84 these rectangular icons change color responsive to selection so as to place the images in the image cart. The positioning of these icons relative to images can be seen for example in displayed images represented in FIGS. 62 through 64. When scrolling through the images using the control panel 472 the user is selectively enabled to click on those images that they find of interest for purposes of downloading by changing the color of the image cart symbol 474 adjacent to the image of interest. As explained in FIG. 78 a viewer icon 476 may be selected at any time on the control panel to enable a user to quickly view those images that they have included in the image cart.

A further useful aspect of the exemplary embodiment of the present invention is the ability to transfer the images in the image cart from the device 330 in a manner that provides greater assurance that the images have not been subject to tampering. In the exemplary embodiment of the invention a user is enabled to download images using the image cart feature to a terminal. However device 330 is programmed so as to include in connection with such images a warning to

indicate to the viewer thereof that the image was not secure and may be subject to tampering. Given the ability of current computer equipment to do image modification and manipulation, this feature assures that images which are downloaded without security give any user thereof fair notice that the image may not be as originally captured. This notice is preferably sent with the downloaded image when the data corresponding thereto is transferred to the user terminal and the image is output on a display thereof.

The image cart feature however enables the application of a digital signature with images downloaded in the image cart along with the associated data. This security feature is attained by selecting a key icon **477** in the control panel as shown in FIG. **78**. In response to selection of the key icon **477** a user downloading images is presented with a screen of the type shown in FIG. **85**. The screen advises the user that the images are being downloaded as a secure file to assure integrity. In addition the user is provided with a password which must be input to unlock the package of image and transaction data which has been secured with the digital signature. In the exemplary embodiment, the images are also downloaded with an encryption scheme which is integrated with the digital signature technique to assure that only the authorized user may access such images. Of course it should be understood that this technique is exemplary and in other embodiments other approaches to encrypting the data as well as techniques for reducing the risk that images have not been subject to tampering may be used.

Thus the new transaction record system and method of the present invention achieve the above stated objectives, eliminate difficulties encountered in the use of prior devices and systems, solve problems and attain the desirable results described herein.

In the foregoing description certain terms have been used for brevity, clarity and understanding, however no unnecessary limitations are to be implied therefrom because such terms are used for descriptive purposes and are intended to be broadly construed. Moreover, the descriptions and illustrations herein are by way of examples and the invention is not limited to the exact details shown and described.

In the following claims any feature described as a means for performing a function shall be construed as encompassing any means known to those skilled in the art as being capable of performing the recited function and shall not be deemed limited to the particular means shown in the foregoing description or mere equivalents thereof having described the features, discoveries and principles of the invention, the manner in which it is constructed and operated, and the advantages and useful results attained; the new and useful structures, devices, elements, arrangements, parts, combinations, systems, equipment, operations, methods, processes and relationships are set forth in the appended claims.

We claim:

1. A method comprising the steps of:

(a) storing data corresponding to a sequence in a data store in operative connection with a computer, wherein the sequence includes data representative of at least one triggering event and at least one action to be carried out responsive to the triggering event;

(b) sensing for the triggering event through operation of the computer;

(c) carrying out the at least one action in the sequence responsive to the triggering event through operation of the computer, wherein the at least one action includes capturing at least one image from a camera; and

(d) storing in the data store responsive to operation of the computer, data representative to the triggering event and data corresponding to the at least one image.

2. The method according to claim 1 and prior to step (b) further comprising the steps of periodically capturing images from the camera; and storing in the data store in correlated relation with the data representative of the triggering event, data corresponding to at least one image captured immediately prior to occurrence of the triggering event.

3. The method according to claim 1 wherein in step (a) the triggering event in the sequence includes sensing an image condition corresponding to lack of usable video from a first camera, and an action in the sequence includes capturing an image from a second camera, wherein in step (d) data corresponding to an image from the second camera is stored in the data store.

4. The method according to claim 3 wherein sensing lack of usable video includes sensing lack of contrast in an image captured from the first camera.

5. The method according to claim 3 wherein sensing lack of usable video includes sensing intensity of a plurality of pixels included in the image and determining that a quantity of the pixels are either above or below high and low thresholds, respectively.

6. The method according to claim 1 wherein in step (a) the triggering event includes sensing motion by detecting differences between a plurality of images captured from a first camera.

7. The method according to claim 6 and prior to step (b) further comprising the step of selecting a detection area within a field of view of the first camera, the detection area being less than the field of view, and wherein in step (a) the triggering event in the sequence includes sensing motion in the detection area.

8. The method according to claim 6 and prior to step (b) further comprising the step of:

(e) storing in operative connection with the processor, degree data wherein the degree data corresponds to a degree of change in a plurality of pixels in the detection area, which degree of change corresponds to motion, and wherein step (b) includes sensing for the degree of change in the plurality of pixels in the detection area between a plurality of captured images.

9. The method according to claim 8 wherein in step (e) the degree data corresponds to both a change in property of the pixels in the detection area and a quantity of the pixels which undergo such change in property.

10. The method according to claim 1 wherein at least one action in the sequence includes data representative of sending at least one e-mail to an e-mail address, wherein in step (c) the computer is operative to cause the e-mail to be sent.

11. The method according to claim 10 wherein the e-mail sent in step (c) includes therewith at least one image captured by the camera.

12. The method according to claim 10 and further comprising prior to step (b) storing a group comprising a plurality of e-mail addresses in the data store, to be notified in the event of the occurrence of a triggering event, and wherein in step (a) an action in the sequence includes sending an e-mail message to the group, and wherein in step (c) the computer is operative to cause an e-mail message to be sent to the group.

13. The method according to claim 1 and further comprising prior to step (b) the steps of:

storing in the data store data corresponding to at least one recognizable image;

and wherein in step (a) the triggering event includes the presence of the at least one recognizable image in an image captured by the camera.

14. The method according to claim 13 wherein the recognizable image includes at least one human face.

15. The method according to claim 13 wherein the recognizable image includes at least one weapon.

16. The method according to claim 13 wherein the recognizable image includes at least one type of clothing.

17. The method according to claim 1 and prior to step (a) further comprising the step of:

assigning descriptive designators to each of a plurality of cameras, and wherein the sequence data stored in step (a) is input using the descriptive designators.

18. The method according to claim 17 wherein in step (d) the data representative to the triggering event includes a descriptive designator corresponding to a camera capturing the image.

19. The method according to claim 1 wherein the computer is operatively connected to an automated banking machine and wherein in step (a) at least one triggering event in a sequence corresponds to conduct at least one transaction step at the automated banking machine, and wherein an action in the sequence includes capturing an image of a user of the banking machine, and wherein in step (d) an image of the user is stored in the data store.

20. The method according to claim 19 and further comprising the steps of:

conducting a transaction at the automated banking machine, wherein the conduct of the transaction is operative to cause the generation of transaction data corresponding to the transaction;

and wherein in step (d) data representative of the transaction data is stored in the data store.

21. The method according to claim 20 wherein the transaction data stored in (d) includes data representative of at least one time associated with the transaction.

22. The method according to claim 20 wherein the transaction data stored in (d) includes data representative of a user name associated with the user conducting the transaction.

23. The method according to claim 20 wherein the transaction data stored in step (d) includes data representative of an account number associated with the transaction.

24. The method according to claim 20 wherein the transaction data stored in (d) includes data representative of a transaction type associated with the transaction.

25. The method according to claim 20 wherein the transaction data stored in step (d) includes data representative of an amount associated with the transaction.

26. The method according to claim 21 and further comprising the steps of searching the data stored in the data store by transaction time, and recovering from the data store at least one stored image based on the transaction time associated with the transaction.

27. The method according to claim 26 wherein the transaction time includes a time period, wherein in the recovery step images are recovered responsive to a time associated with a transaction being within the time period.

28. The method according to claim 24 and further comprising the steps of searching the data stored in the data store by transaction type, and recovering from the data store at least one stored image based on transaction type associated with the transaction.

29. The method according to claim 20 wherein the transaction data includes at least one transaction parameter, wherein the transaction parameter includes at least one of a time, a user name, an account number, an amount and a transaction type.

30. The method according to claim 29 and further comprising the steps of searching the data stored in the data store by at least one transaction parameter associated with transactions, and recovering from the data store at least one stored image corresponding to the at least one parameter.

31. The method according to claim 29 wherein the transaction data includes at least two parameters, and further comprising the steps of searching the transaction data stored in the data store for the at least two parameters, and recovering from the data store at least one image corresponding to a transaction having the at least two parameters associated therewith.

32. The method according to claim 29 wherein the transaction data includes at least two transaction parameters, and further comprising the steps of:

including an image deletion routine in operative connection with the computer operative to delete images corresponding to a first transaction parameter from the data store while retaining images corresponding to a second transaction parameter;

deleting data from the data store corresponding to images responsive to operation of the image deletion routine in the computer, wherein the deleted images correspond to the first transaction parameter.

33. The method according to claim 32 and further comprising the step of sensing for available storage in the data store, and wherein in the deleting step the deletion of data is initiated responsive to available storage reaching a first level.

34. The method according to claim 32 wherein in the deleting step the deletion of data is stopped responsive to available storage reaching a second level.

35. The method according to claim 1 wherein at least one of the actions in the sequence stored in step (a) includes capturing images on a generally continuous basis from at least one camera, and wherein in step (d) the generally continuous video images are stored in the data store.

36. The method according to claim 35 wherein the generally continuous video images stored in step (d) are captured at a rate of at least ten frames per second.

37. The method according to claim 1 and further comprising the step of:

selectively deleting from the data store data corresponding to images by a type of triggering event causing the image to be stored, wherein data corresponding to images associated with at least one type of triggering event is deleted from the data store and wherein data corresponding to images associated with at least one other type of triggering event is retained.

38. The method according to claim 37 wherein a first type of triggering event is associated with an alarm condition, and a second type of triggering event is associated with other than an alarm condition, wherein in the deleting step data corresponding to images associated with the second type of triggering event are deleted.

39. The method according to claim 37 and further comprising the step of storing in connection with the computer an image deletion routine, and wherein the computer operates to delete data corresponding to images associated with the at least one type of triggering event responsive to storage in the data store reaching a first level.

40. The method according to claim 39 wherein the computer is operative to discontinue the deletion of image data responsive to the storage in the data store reaching a second level.

41. The method according to claim 37 and further comprising storing an image deletion routine in operative connection with the computer, wherein the image deletion routine is operative to cause the computer to execute the deleting step wherein data corresponding to images is deleted in response to a type of triggering event causing the image to be stored and an age of the stored data corresponding to the image.

42. The method according to claim 1 wherein the triggering event corresponds to a time.

43. The method according to claim 1 and further comprising the steps of:

storing in operative connection with the computer, data representative of at least one visual characteristic in the image;

searching the data corresponding to images in the data store for the visual characteristic;

identifying those images including the visual characteristic.

44. The method according to claim 43 wherein the visual characteristic includes at least one physical characteristic.

45. The method according to claim 43 wherein the visual characteristic includes at least one facial characteristic.

46. The method according to claim 45 wherein the facial characteristic corresponds to a face of a particular person.

47. The method according to claim 43 wherein the visual characteristic includes a particular article of apparel.

48. The method according to claim 43 wherein the visual characteristic includes a particular color.

49. The method according to claim 43 wherein the visual characteristic includes an image of a particular device.

50. The method according to claim 49 wherein the device includes a weapon.

51. The method according to claim 1 and further comprising the steps of;

storing in the data store, data corresponding to a plurality of images associated with a plurality of triggering events;

displaying at least one image corresponding to each triggering event on a display.

52. The method according to claim 51 wherein actions in at least one sequence include capturing and storing data corresponding to a plurality of images, and wherein in the displaying step a plurality of images corresponding to the triggering event are displayed as a set on the display.

53. The method according to claim 52 and further comprising the step of capturing and storing in a data store data corresponding to a prior image captured by at least one camera prior to occurrence of the triggering event, wherein the prior image is included in the displayed set.

54. The method according to claim 51 and further comprising the steps of:

providing on the display at least one icon, and navigating through a plurality of images responsive to selection of the icon with an input device.

55. The method according to claim 51 and prior to step (d) further comprising the step of storing a data compression parameter in operative connection with the triggering event, wherein the data corresponding to the image stored in step (d) is compressed in accordance with the data compression parameter.

56. The method according to claim 1 and further comprising the steps of:

providing a server in operative connection with the data store;

accessing stored data corresponding to the image at a user terminal in operative connection with the server.

57. The method according to claim 56 and further comprising the step of including through operation of the computer a digital signature with the accessed stored data corresponding to the image.

58. The method according to claim 56 and further comprising the step of transferring data corresponding to the image to the user terminal.

59. The method according to claim 58 wherein the step of transferring the image to the user terminal includes transferring a key which enables reproducing the image at the user terminal.

60. The method according to claim 56 and further comprising the steps of;

requesting transfer of the data corresponding to image not including a digital signature with the user terminal;

including through operation of the computer an indicator in connection with the data corresponding to the image that the image may have been subject to modification; and

transferring the data corresponding to the image with the indicator to the user terminal.

61. The method according to claim 60 and further comprising the steps of:

providing an input through an input device at the user terminal that an image is to include a digital signature;

including through operation of the computer a digital signature in connection with the image;

transferring the data corresponding to the image to the user terminal with a key usable to verify the genuineness of the image.

62. The method according to claim 51 and further comprising the steps of:

selecting at least one image through an input to an input device, and transferring the data corresponding to the selected image to a remote user terminal.

63. The method according to claim 62 and wherein the input is operative to cause a visible marking indicating the selected image to be included on the display.

64. The method according to claim 62 wherein in the selecting step a plurality of images are selected, and further comprising transferring the data corresponding to the plurality of images as a batch to the remote user terminal.

65. The method according to claim 64 and further comprising including a digital signature in each of the plurality of transferred images responsive to operation of the computer.

66. The method according to claim 64 wherein in the transferring step the data corresponding to the images is transferred to a remote user terminal through a network.

67. The method according to claim 66 wherein the data corresponding to the images is transferred through the Internet.

68. A method comprising:

(a) storing data corresponding to a sequence in a data store in operative connection with a computer, wherein the computer is operatively connected to an automated banking machine, wherein the sequence includes sequence data representative of at least one action to be carried out responsive to at least one triggering event, wherein the at least one triggering event corresponds to conducting at least one transaction step at the automated banking machine;

(b) detecting the least one triggering event through operation of the computer;

(c) carrying out the at least one action in the sequence responsive to the triggering event through operation of

the computer, wherein the at least one action includes capturing at least one image;

(d) storing in the data store responsive to operation of the computer, data related to the triggering event and data corresponding to the at least one image.

69. The method according to claim 68 wherein (c) includes capturing at least one image of a user of the automated banking machine, and wherein (d) includes storing at least one image of the user in the data store.

70. The method according to claim 69 and further comprising

(e) prior to (b), capturing at least one pre-triggering event image; and

(f) storing the at least one pre-triggering event image in the data store in correlated relation with the data related to the triggering event.

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